Financial performance studies of University Spin-Off companies (USOs) in the West Midlands

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Peter David Jelfs

Thesis submitted for the degree of PhD

Birkbeck, University of London

Abstract

Doubts remain over the true success of USOs in the UK, particularly those created outside the elite research universities. This thesis examines the financial performance of USOs generated from universities with a range of research intensities from a single region, the West Midlands, and considers whether observations can be rationalised using the frameworks of signalling and agency theories.

While some results are in line with the expectations of the frameworks, others are not and demonstrate the complexity in attempting to explain the data, and the need to consider wider data sets and more explanatory factors.

Universities with a strong research pedigree generated the most USOs in line with the theoretical frameworks, with the Russell Group universities dominant in the region. The data relating to survival of USOs is more difficult to rationalise and leads to a tentative conclusion that this is not a useful performance metric. External funding appears to be in line with prior studies e.g. Shane (2004) and the theoretical frameworks in that the total funding obtained by a university is positively correlated to its research strength, although the Russell Group member Warwick shows an exceptionally high level of funding obtained. Finally, the data on exits demonstrates the inability of all universities across the region to generate financially successful exits. In fact, the only financially successful exit was by a USO that had no external funding, demonstrating a lack of commercialisable technology created across the region.

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I confirm that the work presented in this thesis is my own.

Peter Jelfs, 31 October 2018

Dedicated to:

Allison Jelfs

Ivan Jelfs

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Chapter 1: Introduction

1.1 Background and importance of USOs in the UK

University spin-off companies (USOs) have become a significant feature of the UK's further education sector landscape since the late 1990s. UK universities have been encouraged by successive governments to develop and expand a 'third mission' (Chatterton and Goddard, 2003; Visintin and Pisano, 2014) of, amongst other things, economic development through technology transfer (Etzkowitz, 2002). Such activities were expected to sit alongside their traditional missions of teaching and research, and USOs have increased in number to become possibly the most visible manifestation of this strategy.

Within the wider purview of this 'third mission', stakeholders including governments, policy makers and universities have identified early-stage and potentially disruptive technologies created at universities as having the potential to be developed to reach a stage where they can be commercialised and generate income for their owners (Lambert, 2003; Soetanto and Geenhuizen, 2015). Historically, such intellectual property had been owned indirectly by the UK government via the government-owned British Technology Group as public money had been used in the technology's development. However, during the 1980s, and in line with the pioneering Bayh-Dole Act of 1980 in the US, legislation was enacted which allowed UK universities for the first time to retain the intellectual property rights arising from research that was publicly funded (Richards, 2009). It should be noted that not all UK universities enacted their rights to ownership until much later, with the academic behind the development of such rights often owning them.

The downward pressure on funding availability from public revenues to enable the undertaking of early-stage research at universities meant that potential financial returns to the parent institution through USOs and other forms of technology commercialisation became an increasingly attractive prospect (Siegel and Wright, 2015). Such hopes were given credence by the apparent financial success of USOs from the US (Geuna and Rossi, 2011). The UK government released significant public funds, particularly in the form of University Challenge Funds (UCFs) from 1999, to help universities set up USOs and overcome the well-known funding gap that all new companies trying to commercialise an innovative technology face while still in the development phase.

Given the financial incentives available, it is perhaps unsurprising that the number of USOs in existence increased significantly from about the year 2000 as many UK universities fully embraced the government's vision. Numbers of USOs formed each year increased from fewer than 10 in 1994 to over 100 by 2001 (Mueller, 2010). New and refurbished infrastructure such as technology transfer offices (TTOs) and incubatory facilities became a common sight on university campuses, together with significant investment in the staff working within these operations (Shane, 2004). Some of the USOs created were also able to attract funding from the private investment sector, which gave further hopes that, bearing in mind the due diligence such organisations perform before investing, genuinely disruptive and commercialisable technologies were being found and developed. These patterns were also observed in overseas countries, which followed the lead of the US (Wennberg *et al.*, 2010).

However, once the initial burst of USO creation activity slowed, some commentators e.g. Lambert (2003) started to discuss the need for a number of thorough reviews of the actual financial performance to date of such USOs. While the numbers of USOs created were increasing significantly, such a metric said nothing about the underlying success of the companies created. Studies were performed using non-financial metrics, which are certainly of importance, but the study of financial performance at a company level would be crucial in providing comfort to all stakeholders that the policy of USO creation was meeting one of its aims of creating wealth. Critics of the USO programme focused on the apparent measurement by certain commentators of the success of the UK's USO programme by considering the quantity of USOs generated rather than their quality (Fini *et al*., 2017), and ignoring more challenging performance measures such as the amount of third party finance attracted by the companies (Lambert, 2003; Guthrie, 2004). The lack of a UK USO to reach the size of their largest US counterparts, and indeed the more general apparently inferior performance of UK universities in generating revenues, employment and financial value from their USO programmes, when compared with the US, has also been noted (RSC, 2005). The financial performance of USOs was also unfavourably compared to that of corporate spin offs (CSOs) in a number of studies (Zahra *et al*., 2007; Wennberg *et al*., 2011).

As time passed, however, despite the desire for a significant body of work, the number of studies of detailed financial performance of USOs increased only at a very slow rate (Wennberg *et al.*, 2010), as well as studies over the long-term viability of USOs (Meoli *et al*., 2013). This can be attributed to a number of factors which will be discussed at much greater length, but difficulty in obtaining reliable and complete financial data was, and remains, a key issue. Inevitably, a number of commentators started to question whether USOs were delivering any tangible financial benefits, and indeed whether they were even covering the costs of servicing the infrastructure set up to support USO creation. A picture is painted of a large number of very small USOs in the UK which were not justifying the investments and hype surrounding them, as well as in other countries (Fini *et al*., 2017; Iaccobuci *et al*., 2011). Harrison and Leitch (2010) described the phenomenon of USOs as a 'voodoo institution' where hard evidence for backing up claims of success is lacking. Other researchers noted the fact that most USOs tend to remain very small (Hesse and Sternberg, 2017). From a government and public policy perspective, studies into the financial performance of USOs are thus of great importance, given the fact that large sums of public money have been invested in these programmes of USO creation (Wright *et al*., 2008).

In a similar vein, Rasmussen *et al.* (2012) note that, given the prominence of USOs in government policies to promote economic growth, empirical evidence on their impact is limited, with some of the apparent success stories of companies created by universities being based on very broad definitions. In addition, a small share of universities are responsible for a high proportion of USOs created, and the literature to date often uses empirical data from the most successful cases. Most studies consider only anecdotal evidence or case studies of a single university or region, and it is not clear if conclusions can be transferred to other contexts. It can be seen from above that a number of financial performance studies have been undertaken to date, but the conclusions that may be drawn are limited.

1.2 Motivation and contribution to the literature

The overarching aim of this thesis is to add to the understanding of the topic of the financial performance of USOs. It should be noted that there are other, non-financial ways to measure performance, but these are not considered in depth given the nature of the data to be collected. The overall success, or otherwise, of USOs in the UK is a topic that still requires further study, almost twenty years after the increase in numbers, and given the passing of time the data available will allow a useful assessment to be made.

In terms of a conceptual contribution to the literature, this thesis evaluates the theoretical frameworks used to date in the studies of financial performance of USOs and identifies the most suitable both for this work and to allow easy comparability with future studies as signalling and agency theories. While other frameworks such as the Resource-Based View (RBV) have been popular in studies of USOs to date, these are less appropriate to this work given the restricted nature of the financial data collected. It adds to the literature by providing an analysis of the performance metrics used to date in other works and a justification of those used that produce the best means to discover whether the overall programme of USOs in the UK has been a success, as well as considering how these metrics are linked and builds a performance model that can be used in further work. It also seeks to link performance data obtained back to the chosen theoretical frameworks to see if findings are consistent with the hpredictions of the frameworks, while recognising that financial performance is dependent upon a wide range of factors meaning that any conclusions are likely to be tentative in nature.

The thesis further seeks to make a significant contribution by helping to partially fill the evidence gap mentioned above in the academic literature on the financial performance of UK USOs. However, the motivation to further research this topic is slightly broader and attempts to address a number of potential methodological deficiencies in the existing literature. Those existing studies that do seek to explore this field often appear to use samples of USOs that, while relatively easy to obtain, are likely to miss out a number of interesting cases and may present a distortion of the true picture, inaccurately estimating the financial success of USOs (Shane and Stuart, 2002). As a result, the findings of previous works are often incomplete and thus difficult for policy makers and investors to form judgments over the effectiveness of USOs in commercialising technology.

As noted above and discussed in greater depth in Chapter 3, many existing studies obtain their USO populations and financial performance data either from university TTOs, or directly from USOs themselves. Neither of these sources is necessarily likely to provide an objective source of data in isolation, particularly in regard to USOs that failed from a financial performance perspective and which may have simply been forgotten, resulting in potential survivor bias in their populations (Shane and Stuart, 2002). It is therefore difficult for existing studies to adequately explain unusual results. For example, a number of prior studies have discovered that USOs appear to survive for longer than other start-up companies e.g. Shane (2004), yet due to uncertainties over the accuracy and completeness of their population of USOs from an institution, their explanations for this phenomenon remain disputed e.g. Zhang (2009), although it should be noted that some USOs will need to spend a long time to develop their particular technology (Pettersen and Tobiassen, 2012). Companies that survive without demonstrating a positive financial performance have been identified in other parts of the literature e.g. 'living dead' companies (Ruhnka *et al.*, 1992), but this issue has not been explored in any detail in the USO literature. Existing studies of USOs usually attempt to bypass such issues by not making any

attempt to research and present absolute performance data, but instead use regression techniques to assess the impact of various variables upon a chosen performance measurement e.g. Mueller (2010). While such studies are of value, they are of limited use to policymakers in particular, who wish to focus on absolute results of the USO programmes undertaken to provide justification or otherwise for the absolute value of financial investment made into them. This thesis aims to provide policymakers with a clear picture as to whether the USO creation programme within the West Midlands was successful from a financial perspective.

As a result, this thesis's potentially most significant contribution towards the academic literature is by studying financial performance of USOs using a different methodology from many previous studies while testing out the validity of the two main theoretical frameworks chosen. It places a very significant emphasis upon creating a very accurate dataset of USOs using strict definitional criteria, and a significant proportion of the time spent on this work was in planning and completing this task. It seeks to overcome the issue of survivor bias to which many previous studies are prone by considering a range of objective sources independent of the university technology transfer organisations, combining the findings and then by meticulously reviewing records from earlier years to obtain the required information. Financial performance data is largely extracted from review of the published accounts of each USO rather than relying upon less accurate sources, given that accounting data in the public domain, although sometimes limited in scope, is likely to be more accurate than other forms of data used to date given legal public reporting requirements. Once this accurate data set has been obtained it will be possible to analyse trends across the universities chosen at a granular company level, and over a significant period of time. Importantly, the techniques used will be easily replicable for other areas of the UK for future studies given the nature of the research paradigm in which this research is performed.

In addition to contributing to the literature with high quality data, this thesis also adds a different dimension with the choice of region in which the USOs and universities are studied, namely the West Midlands area of the UK, commonly considered to be a post-industrial region. The heritage of the West Midlands area is largely represented by that of different forms of heavy industry such as pottery in the Stoke region, metalwork and manufacturing in the Birmingham region, and automotive and supporting industries, which attract significant amounts of research from academia and industry in the Coventry and Warwickshire areas (Amison and Bailey, 2014). USOs in these sectors might therefore be expected to be observed in significant numbers in the region. Such industries are still very much present in these traditional areas, but now employ far fewer people in absolute terms than in previous years and are likely to be carried on in smaller industrial units and employing more highly skilled workers. The region itself also shows a wide range of universities from research-intensive Russell Group[1] members (a grouping of the UK's most prestigious research universities) such as Warwick and Birmingham to much newer universities with less research pedigree.

It should be noted that the study of USOs from a single geographic region rather than nationally or from a single university (Fini *et al*., 2017) is, in itself, unusual in the literature. This observation is surprising as the wide range of types of universities within the sample gives rise

[1] The Russell Group of universities, formed in 1994, represents 24 leading UK universities with its aim 'to help ensure the universities have the optimum conditions in which to flourish and continue to make social, economic and cultural impacts through their world-leading research and teaching'.

to a number of interesting comparisons between data collected within the same region, and explanations based upon the profile of the parent institutions, before even considering comparisons with universities in the rest of the UK and overseas, which could be replicated in other studies. The difficulty in obtaining objective data, discussed in greater depth below, is likely to be the root cause of this omission to date.

Universities from such post-industrial areas have not been considered in the UK USO literature in great detail to date, which has often focussed on institutions such as Oxford (Lawton Smith and Ho, 2006), Cambridge (Garnsey and Heffernan, 2005) and London Universities (Holi *et al*., 2007; Lawton Smith *et al*., 2014), which constitute the elite UK universities with particularly strong and well-funded science and engineering departments, from which the majority of USOs traditionally originate. This study will therefore provide a perspective on a different tier of UK universities and determine whether the USO phenomenon has provided any significant financial benefits to them, as doubts remain as to how far the findings from such elite universities are replicated (Wright *et al*., 2008). It will serve to complement a study of the redbrick Queen's University, Belfast by Harrison and Leitch (2010) and provide further insight as to whether the performance of USOs justifies the resources invested in them. It further compares and contrasts findings from other works in the literature with its own data, which is surprisingly a topic that has rarely been performed to date e.g. Mueller (2010), possibly due to the wide range of performance data collected which appears to be largely driven by the source of data at hand to the researchers. As a result the financial data may be able to contribute to some extent to the wider area of national and regional support for USOs and how policy makers can seek to achieve this, or even if such support is actually the most effective use of resources in attempting to commercialise university-developed technology.

As noted above, the West Midlands region has a wide range of universities, and therefore unsurprisingly a wide range of attitudes towards the creation and support of USOs generated to exploit and commercialise their technology. These range from establishing substantial technology transfer offices with dedicated staff, often with private sector experience, who actively seek out university technology with commercial potential, as in the case of Warwick, to more low key operations, as seen amongst some of the newer universities where USOs are supported in a non-financial way. A number of newer universities in the region generated no USOs at all. The table below provides some examples of this range of support.

Active support	**Less active support**
Technology transfer office established	No technology transfer office established
Employees with private sector experience recruited to assist USOs	University staff assist USOs
University recommends external directors to USOs	University does not recommend directors
University has close relationships with external investors	Few or no relationships with investors
Unversity provides low-cost incubator space to USOs	USOs must seek external premises
University creates a strong, positive culture of entrepreneurship amongst staff and students	Entrepreneurial culture not developed

University secures external professional advisers to offer free or discounted services to USOs	Few or no relationships with professional advisers
University hosts networking events with investors and entrepreneurs	Few or no external events or interactions
University offers practical entrepreneurship modules or courses	Few or no relevant modelules or courses
University selectivelyinvests in equity of USOs	No investments made

Table 1.1 Range of university support for USOs (author-generated)

1.2.1 Unit of Analysis

The unit of analysis of this work is the USO i.e. the limited company 'spun off' from the university to attempt to commercialise technology. This is a clear consequence of the desire to collect detailed historic accounting data from company records. A limited company is a discrete legal entity and forms a suitable unit of analysis for study. However, there are significant relationships between a USO, the university (including any associated technology transfer operations) from which the USO is derived, and the region in which it is located. All these elements are of interest to explore where possible as noted in the preceding paragraphs. For instance, it is well known that universities have very different policies and create a very wide range of USOs, ranging from zero to significant numbers (Shane, 2004; Rasmussen *et al*., 2012), and there are also significant regional variations (Minshall and Wicksteed, 2010).

As a result, it is acknowledged that it may be difficult at times to separate USOs from their parent university, and potentially the wider region, when discussing the results. It may be necessary to group together USOs under parent universities or region, especially when comapring results with the small number of existing studies in the literature, and it should be borne in mind that a number of USOs under examination will no longer exist. However, the real value and novelty of this work lies in the methodology of collection of data from different sources to prior work as noted above; it is not simply the study of USOs from a new region. It is hoped that the accuracy of the new approach will allow comments to be made on existing studies, offering possible solutions to queries raised to date.

1.3 Research questions

Based on the above motivations behind this thesis to contribute towards the academic literature on USOs, the broad overarching research question which this work seeks to answer is:

'Have USOs generated by West Midlands universities been successful in terms of financial performance?'

In order to answer this question, it is critical to identify the most effective performance metrics with which to evaluate the USOs, and the following associated methodological question is further researched in Chapter 3:

'What are the most effective financial performance metrics for studying the performance of USOs?'

Several supplementary research questions relating to the interaction and links between key performance metrics identified are further developed in Chapter 3 in order to build a model that can be replicated in future studies.

1.4 Thesis structure

Following this introductory chapter, the thesis is broken down into a number of further chapters to explore the chosen theme.

As noted above, the current academic literature relating to USOs is relatively small compared to other fields, as would be expected when dealing with a new area of study, but growing fairly rapidly. Chapters 2 and 3 of this work undertake a detailed review of the existing academic literature relevant to USOs. Chapter 2 focusses on the growing literature examining the wider topic of universities and entrepreneurship, including key topics such as government policies worldwide to encourage the development of this area, before focussing on the part of this literature that considers USOs. Important issues are introduced such as a review of previous attempts to define a USO, consideration of the heterogeneity of USOs and attempts to classify them into different typologies. Chapter 3 reviews the key performance metrics, as well as theoretical models used to date in the literature to study USOs, before selecting those metrics that are most suitable for the current work and the theoretical frameworks within which to collect and analyse the financial performance data obtained.

Chapter 4 investigates the research paradigm within which the research is carried out, and also explains the research methodologies and design to be used in the present work, justifying the choices made.

Chapter 5 presents a case study of the University of Birmingham, focussing on the financial performance of its USOs using the metrics and methodologies selected in the previous chapters to test their validity for use in the whole thesis. The University of Birmingham falls within the overall population of universities from the West Midlands, and a case study on a single university was run to test whether the proposed methodology for the whole work was realistic and that sufficient data could be collected and analysed. This chapter formed the basis of a published journal paper (Jelfs, 2016).

Chapter 6 expands upon the single university case study of the previous chapter, using the same metrics and methodologies that had previously proved successful, to include all the universities throughout the West Midlands region. The data for all the universities is collated to allow more detailed subsequent analysis to be performed.

Chapter 7 compares and contrasts the data collected between the universities within the West Midlands region and draws out trends across the region. It analyses results and trends within the theoretical frameworks chosen in Chapter 3 and attempts to provide explanations for trends observed that are of particular interest.

Chapter 8 follows on by comparing and contrasting the West Midlands universities' data with data collected in other academic studies, which cover USOs derived from both other UK and overseas universities. The number of comparable studies in the academic literature is currently very low, but some interesting comparisons are able to be drawn, as well as validation of data collected in these other studies.

Chapter 9 provides discussion points for key USO stakeholders arising from the thesis, conclusions arising and suggestions for further work to be performed within the field to build on the findings of this work. It also provides answers to the research questions raised in Chapter 4 based on the financial data collected, and concludes on the validity of the theoretical frameworks of signalling and agency theories.

Chapter 2: Literature Review

2.1 Introduction

The purpose of this chapter is to introduce the topic of USOs. A literature review highlights key issues related to USOs that have been studied to date, and their relevance to the subjects of investigation of this thesis.

The chapter starts with a brief review of key concepts and definitions from the academic literature about the interaction between universities and entrepreneurship, of which USOs are a part. It then considers government policies introduced to encourage universities into undertaking entrepreneurial activities, including financial support for USOs. The remainder of the chapter then focusses on USOs at a company level, and considers key issues from the literature such as definitions of USOs, the heterogeneity of their properties and typologies proposed to date, which will be important concepts to consider within the research design of the current study. Finally, regional and institutional aspects are also briefly considered given the importance of the West Midlands region in this thesis.

2.2. Universities and entrepreneurship

USOs form an important part of a much wider range of interactions between universities and entrepreneurship. This section considers very briefly some of the background from the literature concerning this relationship, before the chapter moves on to consider USOs in more detail.

Since the founding of mediaeval universities, their two key activities have usually been teaching and research. Martin and Etzkowitz (2000) note that the roles attributed to universities have evolved according to two main perspectives on the two primary traditional functions:

- The ‘classical university’ generates and transmits knowledge through research conducted for its own sake, and teaching aiming to develop the full potential of students
- The ‘technical university’ focusses on training students with knowledge and skills that are useful for society, and on creating knowledge of direct societal benefit

On a narrow level relevant to the current study, the ‘third mission’ of universities can be described as a mission of economic development through technology transfer (Etzkowitz, 1998). Chatterton and Goddard (2003) consider the mission to be a more wide-ranging concept with a number of proposed definitions encompassing the interaction of universities with society, covering economic, social, cultural and knowledge transfer engagement. This civic role is a particularly important concept for some of the UK’s ‘redbrick’ universities such as Birmingham. The definition of technology transfer is broad, and Harrison and Leitch (2010) note that there has long been a link between university expansion and economic growth, but this was previously based on development of human capital rather than exploitation of academic research.

An ‘entrepreneurial university’ (Etzkowitz, 1983) is an institution that shows entrepreneurial behaviours, although this is much wider than simply considering technology commercialisation.

A recent report by the OECD (OECD, 2012) found little consensus in the literature over how to define such an entity. Gibb (2013) described it as a university 'designed to empower staff and students to demonstrate enterprise, innovation and creativity in research, teaching and pursuit and use of knowledge across boundaries'. An older definition from Clark (1998) describes such a university as one that 'seeks to innovate in how it goes to business, to work out a substantial shift in organizational character, to become stand-up universities that are significant actors in their own terms'.

Governments worldwide have made concerted policy efforts to increase university entrepreneurship, and particularly in the development and commercialisation of their intellectual property. Most commentators appear to acknowledge that this step change in activity was initially observed in the US; Grimaldi *et al.* (2011) consider that the change commenced in the late 1970s following growing concerns over the apparent deterioration of the national competitive advantage in manufacturing, and particularly from increased competition from Japan. Rothermael *et al.* (2007) state that a shift occurred in the US university system to create entrepreneurial universities, driven by the following key contributory factors:

- Rise in venture capital availability
- New legislation, particularly the Bayh-Dole Act mentioned in more detail below, which provided incentives for universities to obtain patent protection for discoveries achieved with federal funding
- Rise in the numbers in the pool and thus the mobility of scientists and engineers
- Important technological breakthroughs in a range of areas, particularly computing, biotechnology and nanotechnology

From a UK perspective, Minshall and Wicksteed (2005) consider that commercialisation activities in UK universities suffered from a poor image internally for a long while, particularly when compared to the US. The process of change has often been considered to have accelerated in 1985 with the Conservative government's ending of the state-owned British Technology Group's monopoly over the ownership of intellectual property rights generated by academics, a policy which gave universities the right to exploit their own inventions, whether publicly-funded or otherwise.

However, the entrepreneurial university concept has also attracted critical analyses over its effectiveness. Holbrook and Hulbert (2007) identify a fundamental change in how a university is viewed as a social institution from one of education and research to a consumerist 'knowledge factory', collaborating closely and increasingly funded by industry and developing a range of client-specific programmes. Further criticisms of the model include some opinions that the entrepreneurial university is a failed idea (Armbruster, 2008), as it raises unreasonable expectations with expected returns failing to materialise, and threatens to compromise the creation of science itself. Tuunainen (2005) considers that the entrepreneurial university pays insufficient attention to 'the problems and contradictions universities encounter as they cater for the new economic functions', while Vestergaard (2007) notes that efforts to commercialise university research are often impeded by role conflicts and tensions between university management and researchers. Bozeman (2000) argues that the 'cooperative technology policy paradigm', which sees technology transfer as a key mechanism for impacting markets, industry competitiveness and economic development, has only a modest potential for creating new jobs or businesses.

2.3 Government policies on supporting USOs

Grimaldi *et al*. (2011) note that there is widespread global agreement on the value of promoting commercialisation of knowledge generated by universities, and a variety of government policies to encourage this behaviour are seen in a number of countries both on a national and regional level, although some recent studies have challenged the need for public support of USOs e.g. Sternberg (2014). Rasmussen (2006) considers that many countries have undertaken university reforms with a view to increase the commercialisation of the results of public research, which have been achieved through changes in academic systems and instruments for research funding, as well as setting up structures to support such activities. The approaches taken have been varied, and an overview of policies in this field in two key geographic areas: the US and the UK, is given below.

As with the encouragement of university entrepreneurship mentioned above, both national and regional governments have introduced policies explicitly to target the creation and support of USOs (Sternberg, 2014; Fini *et al*., 2016). Geenhuizen and Soetanto (2009) state that a major reason for policy attention on USOs in Europe lies in the 'European paradox', which is the apparently contradictory situation of a high level of publicly financed knowledge production at universities and research institutes, but a limited wealth creation achieved through using the knowledge (Wright *et al.*, 2008). This concept has been developed further e.g. the Swedish 'academic paradox' (Edquist, 2002) as more detailed studies have been carried out on a country level. Policies to create USOs at national, regional and university level have been introduced over the last few years. At universities, institutional arrangements such as TTOs and internal seed funds have been set up, but commentators have noted that few institutions have, however, gained a positive revenue from commercialisation activity (Geuna and Nesta, 2006), a situation that this study seeks to explore.

Support for USOs by policy makers has developed with time and this is reflected in a growing literature. As noted in the previous chapter, the primary aim of this work is to collect financial performance data, but this may be able to contribute to the wider debate over the most effective way to support USO development, within the wider context of general national and regional economic development. Guerrero *et al*. (2016) note that many nations, regions and states have attempted to stimultate innovation by companies in order to increase economic growth, and in general these policies, at whatever level, aim to support technology-based entrepreneurship (Mustar and Wright, 2010; Grimaldi *et al*., 2011). Governments support universities as part of this aim (Cohen et al., 2002) and Guerrero *et al*. (2016) consider that the emerging role of an entrepreneurial university focusses on both innovation and entreneurship to contribute to increasing innovation, competitiveness and economic growth (Audretsch, 2014).

Siegel and Wright (2015) discuss the development of policies to support academic entrepreneursip and speculate as to future outcomes within this field given the significant changes seen in recent years. They note that evidence for the success of universities and their TTOs in promoting academic entrepreneurship is limited, and question the applicability of the models of elite universities to most other universities, leading to suggestions over whether many universities should take part at all, or at least focus their efforts narrowly to where they can be most effective.

In terms of future developments, Siegel and Wright (2015) consider that some universities will continue to undertaken academic entrepreneurship, driven by perceived national government policy desires, for three reasons, namely: i) competitive pressures form other universities driven by publication of relevant metrics, ii) to generate money from private donors, and iii) the growth of funding from government agencies. This last point is discussed in more depth below, focussing on the UK, with equivalent US programmes such as the Small Business Innovation Relief and Technology Transfer. In addition, Siegel and Wright (2015) consider that policy makers to date have focussed narrowly on formal intellectual property transfer via licences and USOs, and that significant opportunities exist for informal knowledge creation and exploitation via new forms of entrepreneurial venture. Further evidence of an evolution in traditionalacademic entrepreneurship scholarly analysis is given by Martin (2012) who considers that linking academic research with economic needs has a very long history, certainly predating the recent focus on USOs. Research such as that of Lockett *et al*. (2014) concludes that, in general, many TTOs are inefficient and do not generate positive net income (Abrams *et al*., 2009), which backs up findings such as Grimaldi *et al*. (2011) that the benefit from government policies such as the Bayh-Dole Act were not as great as anticipated, but Siegel and Wright (2015) consider the emerging perspective in academic entrepreneurship to be around the wider social and economic benefit to the university ecosystem, rather than solely considering direct financial returns.

In summary, the academic literature in the field of academic entrepreneurship and USOs is evolving around the area of the support provided by policy makers to encourage national and regional economic development. Earlier practices of essentially direct funding of USOs has been moderated given the lack of financial returns to date to provide broader support and calls for policies such as support for accelerator programmes (Clarysse *et al*., 2015).

2.3.1 US policies

As mentioned above, the US is generally acknowledged to be the worldwide leader in the field of university entrepreneurship, both in terms of the early date of commencement and the scale of the subsequent activity achieved. One widely observed manifestation of government policies in this field is the passing of appropriate legislation to encourage universities to develop entrepreneurial activities (Grimaldi *et al*., 2011). The Bayh-Dole Act of 1980 in the US allowed universities to protect and exploit intellectual property (IP) rights developed from public funding, which they were previously not allowed to do. Mowery *et al*. (2001) note that the Act facilitated university patenting and licensing by replacing agreements negotiated between individual universities and federal agencies with a uniform policy, supporting the negotiation of exclusive licenses between universities and industrial firms for the results of federally funded research, and endorsing of the argument that failure to establish patent protection over the results of federally funded university research would limit the commercial exploitation of these results. This important piece of legislation is often cited as the ‘first in class’ worldwide in government support for university entrepreneurship. A number of European governments subsequently followed suit by passing similar legislation, with the UK leading the way, although exceptions remain such as Sweden which retains the ‘professors’ privilege’ (Geuna and Rossi, 2011), where the academic is the legal owner of their inventions.

In terms of the success of the legislation, Wennberg *et al.* (2011) note that there is evidence that the Bayh-Dole Act, which was intended to facilitate the process by which the knowledge created at universities would spill over to the benefit of the public (Mowery *et al.*, 2004), has fulfilled some of these intentions. Patenting activity of universities and revenues from the licensing of intellectual property both increased in the US following the passing of the legislation (Merrill and Mazza, 2010; Siegel and Wright, 2015), and subsequent reforms such as the founding of TTOs were seen at many universities, with the US leading the way and other countries following suit around the world. Siegel *et al.* (2007) note that in the US, the number of patents granted to US universities rose from fewer than 300 in 1980 to 3,278 in 2005, while licensing of new technologies increased almost fourfold from 1991 and annual licensing revenue rose from $160m in 1991 to $1.4bn in 2005, which reflect an international phenomenon and may in part be attributable specifically to the legislative changes. It should also be noted that there has been some debate over the contribution of the Bayh-Dole Act to society (Verspagen, 2006), and Fini et al. (2010) consider that a wide range of innovation occurs outside the remit of its specific policies, but Thursby and Thursby (2011) found little evidence of a destruction of open culture of science or less basic research work being performed.

2.3.2 UK policies

In the UK**,** following the introduction of the 1985 legislation mentioned above, Mustar and Wright (2010) identify that since the end of the 1990s, the main emphasis of government policies for universities has been the establishment of an entrepreneurial culture in which scientific capabilities are exploited through USOs (and other start-up and spin-off companies), as well as other means. They highlight five main financial initiatives introduced by the UK government to achieve this end, all of which have now expired and not specifically been replaced:

Scheme	Objective	Outcomes/Finance
Higher education reach out to business and the community (HEROBC - 1998)	Funding to support activities to improve linkages between universities and their communities. Intended to initiate a third stream of funding. To reward and encourage HEI's interaction with business.	£20 million per year allocated to provide funding for the establishment of activities such as corporate liaison offices The first round of HEROBC funding ran from January 2000 to July 2003. There were 87 awards ranging from £25k to £1.1m including five collaborative projects. The second round ran from August 2000 to July 2004. There were 50 awards ranging from £100k to £1.1m including 10 collaborative projects.

University challenge (UCF) – first round (1999), second round (2001)	To close the funding gap between basic research and private sector investment by overcoming difficulties faced in trying to fund proof of concept and prototype development work, to demonstrate sufficient success so private investment will follow. Seed investments to help commercialisation of university IPR.	637 institutions (28 universities and 9 Research Council institutes) have access to £65m (£45m from government and charity sources and £20m from universities). Max investment of £250k. Generated tangible increase in spin outs and licensing. In second round, five funds established in which 27 institutions are involved. Each consortium received £3m of government funding to establish the fund, or in some cases to add to funds in the first round.
Science enterprise challenge (SEC) – first round (1999), second round (2001)	To encourage the emergence of a culture that is open to entrepreneurship, which is required for successful knowledge transfer from the science base. Teaching of entrepreneurship to support the commercialisation of science and technology. To produce graduates and postgraduates better able to engage in enterprise. Establish a network of UK universities specialising in the teaching and practice of commercialisation and entrepreneurialism in the field of science and technology.	12 centres of excellence were established with £29m of government funding. Following external contributions, the centres have access to around £57m funding. In second round, 7 consortia (involving more than 30 institutions) were successful and £15m of government investments was made. The majority of awards provided additional funding to centres established by the first round.
Higher education innovation fund (HEIF - 2001)	Third stream funding for universities (additional to teaching and research) building on HEROBC fund. Single, long term commitment to a stream of funding to support universities' potential to act as drivers of growth in the knowledge economy (focus on capacity building and development).	Government allocated £140m over three years from 2001-2. £80m to English HEIs over 2000-4. Second round 2004-6, third round 2006-8, fourth round 2008-11, other allocations up to March 2018 when HEIF closed

Public sector research exploitation fund (PSREF – 2001)	To enable bodies carrying out research on the public sector to support commercialisation and access seed capital funding. Focus on capacity building and development. Focus on knowledge transfer through licensing and spin outs.	£10m awarded in 2001-2, £4m in establishing a seed fund and the remaining £6m to enable 14 consortia, comprising PSREs and more than 30 NHS Trusts to develop capacity in knowledge transfer.

Table 2.1 Main UK government initiatives to encourage university entrepreneurship – Mustar and Wright (2010)

The relevance of these initiatives for this study is that other studies in the literature have observed a significant increase in the number of UK USOs from about the year 2000, which has been ascribed in part to the availability of UCF money (Soetanto and Geenhuizen, 2015). SQW (2005) show that up to July 2003, 413 projects benefited from a UCF investment, translating into 59 USOs, and concluded that 'there is little doubt that UCF met a gap in the UK for early stage funding of technology-based ideas'. As a result, UCF funding will be an important variable in assessing financial performance, as well as discovering whether similar trends are observed in the West Midlands region.

2.4 Definition of USOs

One of the key features and difficulties faced by academic USO research is that there is no consistent definition in the academic literature of a USO (Criaco *et al.*, 2014). This situation is potentially problematic for many reasons, not least the difficulty in comparing results obtained by different studies, and even results within the same study. As an illustration, the Higher Education Funding Council for England's (HEFCE) annual report (the HE-BCI or Higher Education Business and Community Interaction survey - http://www.hefce.ac.uk/ke/hebci), which examines the exchange of knowledge between universities and the wider world, and informs the strategic direction of 'knowledge exchange' activity that funding bodies and higher education institutions in the UK undertake, identifies four categories of USO, namely:

i) Spin offs with some Higher Education Institution (HEI) ownership

ii) Formal spin offs, not HEI-owned

iii) Staff start ups

iv) Graduate start ups

Attempts have been made in the literature to date to collate the various definitions used for USOs, and these are expanded upon below. On first principles, Djokovic and Souitaris (2008) consider that the definition of a USO should specify three key elements:

- the 'outcome' of the spinout process
- the essential 'parties' involved in it
- the 'core elements' that are transferred (spun-out) during that process

Expanding slightly upon these concepts, the first element is the creation of a new company, which appears to be a consensus opinion (Djokovic and Souitaris, 2008) within the literature. The second element principally encompasses the university where the knowledge was developed prior to transfer (Carayannis *et al.*, 1998), although it can include external parties such as USO managers. Shane (2004) considers that companies formed by current or former university employees based on technology developed in a location other than the university are not USOs, although other studies use a more broad definition. The university often provides assistance to the USO such as patenting activities, and often has an equity stake in it. However, the USO is not usually wholly-owned or managed by the university. Roberts and Malone (1996) identified four involved parties in the formation of a USO:

- the parent organisation from which the technology is extracted
- the technology originator i.e. the person who brings the technology from a basic research stage to a point at which technology transfer can begin
- the entrepreneur who attempts to create a new venture centred on the technology
- the venture investor that provides funding for the new company

In addition, the entrepreneur is also a key player who developed the technology. They may continue to work for the university or leave to work in the USO, although some authors consider USOs to be only companies formed by former employees of the university (Carayannis *et al.*, 1998). Externally-hired entrepreneurs may also provide an important role in managing the USO, following the observation of Shane (2002) that the inventor of the technology is not usually the best leader of the USO due to their lack of commercial experience.

The third element covers transfer of rights such as intellectual property, which may be tangible such as patents or intangible such as knowhow, although some studies exclude tacit knowledge-based companies from definition as a USO (Wright *et al.*, 2007). Core elements transferred can also include people, and Djokovic and Souitaris (2008) note that the transfer of people can be defined narrowly as technology being accompanied by people from the parent organisation (Smilor *et al.*, 1990), while Radosevich (1995) distinguished between inventor-entrepreneurs and surrogate entrepreneurs who did not invent the technology but acquired the rights to commercialise it from the university. Nicolaou and Birley (2003) broadened the above definition accepting as a necessary condition for a USO the transfer of technology, but not necessarily people from the parent organisation.

Tietz (2013) provides a comprehensive overview of definitions of USOs from the academic literature, observing that the areas of difference amongst these definitions principally concern the individuals who are involved as entrepreneurs, their relationship to the parent institution and the knowledge or technology on which the business is based. As a result of these factors, the range of different definitions used is striking, and are summarised in Table 2.2 below:

Authors	**Year**	**Definition**
McQueen and Wallmark	1982	'…in order to be classified as a USO three criteria have to be met: (1) the company founder or founders have to come from a university (faculty staff or student); (2) the activity of the company has to be based on technical ideas generated in the university environment; and (3) the transfer from the university to the

		company has to be direct and not via an intermediate employment somewhere'
Smilor, Gibson and Dietrich	1990	'a company that is founded (1) by a faculty member, staff member, or student who left the university to start a company or who started the company while still affiliated with the university; and/or (2) around a technology or technology-based idea developed within the university'
Weatherston	1995	'…an academic spin-off can be described as a business venture which is initiated, or become commercially active, with the academic entrepreneur playing a key in role in any or all of the planning, initial establishment, or subsequent management phases'
Dahlstrand	1997	'an entrepreneurial spin-off arises where an entrepreneur leaves a company to start a firm of his own. To be a spin-off, this must also include the transfer of some rights e.g. assets or knowledge, from the existing legal body to the new firm or body'
Carayannis, Elias *et al.*	1998	'…a new company formed by individuals who were former employees of a parent organisation (the university), around a core technology that originated at a parent organisation and that was transferred to the new company'
Bellini, Capaldo *et al.*	1999	'…academic spin-offs are companies founded by university teachers, researchers, or students and graduates in order to commercially exploit the results of the research in which they might have been involved at the university…the commercial exploitation of scientific and technological knowledge is realised by university scientists (teachers or researchers), students and graduates'
Rappert, Webster and Charles	1999	'University spin-offs are firms whose products or services develop out of technology-based ideas or scientific/technical know-how generated in a university setting by a member of faculty, staff or student who founded (or co-founded with others) the firm'
Clarysse, Heirman and Degroof	2000	'…research-based spin-offs are defined as new companies set up by a host institute (university, technical school, public/private R&D department) to transfer and commercialise inventions resulting from the R&D efforts of the departments'
Klofsten and Jones-Evans	2000	'…formation of new firm or organisation to exploit the results of the university research'
Steffensen, Rogers and Speakman	2000	'a spin-off is a new company that is formed (1) by individuals who were former employees of a parent organisation, and (2) a core technology that is transferred from the parent organisation'
Nicolaou and Birley	2003	'spinouts involve (1) the transfer of a core technology from an academic institution into a new company and (2) the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution'
Clarysse and Moray	2004	'a common two-dimensional definition of a research-based spin-off is a new company that is formed (1) by a faculty member, staff member or student who left university to found the company or started the company while still affiliated with the university; and/or (2) a core technology (or idea) that is transferred from the parent organisation'

Hindle and Yencken	2004	'direct research spin-offs are companies which have been created in order to commercialise IP arising out of a research institution where IP is licensed, involving a patent or copyright, from the research institution to the new firm to form the founding IP of the firm and staff may be seconded or transferred full or part-time from the research institution to the new firm' 'start-ups or indirect spin-off companies are companies set up by former or present university staff and/or former students drawing on their experience acquired during their time at the university, but which have no formal IP licensing or similar relationships to the university'
Shane	2004	'…a new company founded to exploit a piece of intellectual property created in an academic institution'
De Coster and Butler	2005	'university spin-off companies are high-technology ventures that originate from research work in a university, resulting in the generation of intellectual property and, usually, subsequent involvement of key researchers'
Leitch and Harrison	2005	'spin-outs are defined as new companies formed around a core technology discovered in a lab. The parent organisation sells, licenses or somehow transfers the technology to the spin-out, which is often founded by researchers from the parent company or campus'

Table 2.2 Definitions of USOs in the literature – Tietz (2013)

It is noticeable from Table 2.2 that USOs are not a recent phenomenon, as issues of definition were being debated many years before their numbers started to increase significantly. It would appear that over time, definitions have become more specific depending upon the nature of the data obtained, as researchers have started to realise that USOs are heterogeneous in terms of their properties.

In acknowledgement of the difficulty of this issue, one of the key tasks of the current study is to use a strict definition of a USO which can be verified using external data. This gives greater confidence that USOs will be fairly compared like for like within this study, and under a positivist paradigm the definition should enable the data collected to be repeated for other universities, allowing comparisons to be made both with other UK universities as well as foreign ones. The current work will therefore define a USO as a company that met the first HEFCE category for the identification of a USO i.e. 'spin offs with some HEI ownership'. Hence, only companies in which a university held at any time an equity stake are considered. This limitation in scope was considered reasonable for a number of reasons. Firstly, it implies significant university involvement in the creation of the USO via a transfer of intellectual property generated in the university, and a subsequent interest in its financial performance and the commercialisation of the technology. Secondly, the possession of an equity stake also allows the identification of potential USOs from a number of third party, independent sources which can be cross-checked to provide greater accuracy in compiling the database. Finally, such an approach has already been both proposed and used before (Minshall and Wicksteed, 2005).

As already noted, previous studies e.g. Oskarsson and Schläpfer (2008), Mueller (2010) have often relied heavily on questionnaires sent to USOs or technology transfer offices to obtain financial and non-financial data. This study relies solely on a number of third party, independent sources of data to increase the reliability and scope of the information collected, an approach not seen to any significant extent in the literature to date.

2.5 Heterogeneity and Typologies of USOs

One of the main reasons for the difficulty in being able to compare and contrast findings from any study of a population of USOs is the observed heterogeneity amongst the properties of each company. This heterogeneity of USOs may arise through their existing for different reasons, arising from different origins or conducting different activities (Birley, 2002). This is of great importance for the current work, as it implies on first principles that the financial performance of the USOs under investigation will vary significantly across a university or region. As a result, a number of different typologies have been explored in the literature to attempt to classify USOs.

Druilhe and Garnsey (2004) note that studies of technology transfer may tend to depict USOs as a homogenous category, with a linear conception of the process of USO creation where a technology-based idea is generated from research, protected by patents and transferred to a company newly established to commercialise the idea. They question these assumptions and consider that such an approach may restrict understanding of science-based entrepreneurship and impede appropriate support by policy makers. Wright *et al.* (2006) note that certain studies recognise the complexity of problems involved in the development of USOs, which may be associated with the heterogeneity of USOs in terms of their resource endowments, business models and institutional contexts.

In an important study, Druilhe and Garnsey (2004) identified four categories of USO (although they subsequently significantly increased the number of categories in the same paper), which they proposed based upon the activities that they carry out:

1. Consulting USOs
2. Development USOs to complete immature technology development
3. Product companies
4. Software companies

However, USOs will often not fit neatly into one of these categories e.g. a USO could be a software company that also develops immature technology. Druilhe and Garnsey (2004) note that these typologies are useful, but consider that the dynamic processes leading to firm emergence and growth may be overlooked when classifications focus on static categories. They propose a typology linked to the entrepreneurial process of firm formation by drawing on the RBV (Resource-Based View) of the firm.

A number of other attempts have been made to reflect this observed heterogeneity amongst USOs and develop typologies to assist in classification and analysis. One of the key studies in the

literature is that of Mustar *et al.* (2008), who identified at the firm level three very different types of company, which they labelled:

- Venture capital (VC)-backed
- Prospector
- Lifestyle

'VC-backed' USOs are probably the most visible and attractive form from a policy perspective. Their business model is oriented towards convincing stakeholders, particularly investors, about their technology, and while the model may be attractive through its potential growth, there are a number of risks to universities and policy makers. Few research groups have the potential to start such a company which requires a balanced portfolio of technology and which may include buying in or licensing IP. The research group requires recognition in the scientific community and must play a significant role in the market for ideas. It also requires human and financial resources and must be able to attract significant VC funding at start-up to be credible and attract researchers at the university. Mustar *et al.* (2008) state that most USOs will not be VC-backed and, in fact, have limited potential because their technology base is not sufficiently new or credible to play a significant role in the market for new ideas. In this study, it is likely that USOs with successful financial performance will often be found in this category.

'Prospector' companies may attract external finance from public or private equity funds linked to the university. Companies begin with a business model based on consulting or contract research and attempt to find a product to commercialise. Pre-seed funding may not be the best way to finance these companies.

'Lifestyle' companies have a business model based on market acceptance, starting small and following the 'pecking order' of financing (Wright *et al.*, 2006). They may become high growth at a later stage, but even if not their added value may be significant. They are often overlooked by TTOs as they do not involve the formal transfer of technology, but Mustar *et al*. (2008) consider them to form the heart of the entrepreneurial university, and they are less demanding in terms of resources required.

An analysis of the three categories is presented in the following table, which gives a helpful comparison of a range of factors, some of which may be observed in the current study:

	Factor	**VC-backed**	**Prospector**	**Lifestyle**
1. Institutional link	Formal involvement	Equity relation based on a complex IP system	Equity relations based on one patent or none	License, contract, informal relations
	Prestige of research group	Worldwide recognition over a broad domain	Worldwide recognition in a focused subdomain or local recognition	Various
2. Business model	Investor v. market acceptance	Investor acceptance	Both	Market acceptance

	Mode of value capture	Clear IP maximising strategy or value chain acquisition. Strategy to prepare trade sale/IPO	Optimise time to break even and future trade sale value, no clear exit yet	Optimise profit
3. Technology resources	Degree of innovativeness	Disruptive technology or market	New product based on non-disruptive technology	New product/service addresses an unmet market need
	Stage of product/service development	Early, sometimes not even defined	Early, alpha prototype	Almost market-ready product/service
	Broadness of the technology concept	Can be broad	Narrow	Not relevant
4. Financial resources	VC involvement	Able to attract 1-5 M€ in first 18 months after founding	Lower amount of business angels, baby VC or public fund investment	Usually no external equity, some business angel involvement possible
	Financing mix	High level of external equity, some debt financing, intensive use of subsidies	Mix of external capital, soft loans and subsidies	Internal funding, debt and some soft loans
5. Human resources	Balanced team	Surrogate entrepreneur or hired guns	Technical scientists act as entrepreneurs	Technical scientists
	Sectoral experience	Management experience, research excellence	Little experience	Plenty of sector experience
6. Social resources	Partnership at start-up	Formal partnerships with stakeholders (VC, technology providers etc.)	None	Formal availability of lead user

Table 2.3 USO typology analysis – Mustar *et al.* (2008)

In summary, typologies are useful to assist on the classification of USOs, to allow easier assessment of USO properties, but have some obvious weaknesses, not least that there are many different versions. On a similar note, Rasmussen (2006) notes two further weaknesses, in that many USOs can belong to several types at the same time, and the typologies do not account for development over time.

2.6 Regional and institutional aspects

This section briefly considers the regional and institutional context of university entrepreneurship, and in particular USOs. This is of particular significance to the current study, as it considers USOs within a single region, the post-industrial West Midlands.

2.6.1 Regional aspects

The regional dimension to USOs is an area that has not been explored in any significant depth to date. No studies are known of a single region within the UK, and performance studies in the literature to date tend to focus on a single university e.g. ETH Zurich (Oskarsson and Schläpfer, 2008) or a single country e.g. Mueller (2010). As such, this study is an important addition to the literature.

Regional aspects of university entrepreneurship have been considered in more depth. Harrison and Leitch (2010) note the important position of universities in regions in the entrepreneurial system model developed by Spilling (1996) as an enhancer of human capital and a source of knowledge capital which can stimulate entrepreneurial development through licensing, consulting, education and training, joint ventures and USOs. Klofsten and Jones-Evans (2000) state that universities are 'important engines of technological development and growth' and can act as 'catalysts for the enhancement of employment opportunities for local industry', particularly in high-knowledge and knowledge-based sectors, which encapsulates the positive view of the entrepreneurial university which may have driven many government policies. Breznitz (2011) notes that, at a regional level, interactions between universities and other institutions will influence both the entrepreneurial nature of the university and its USOs. Etzkowitz and Leydesdorff's (1997) 'triple helix' model of interaction between universities, government and business is one such model.

In a similar vein, some researchers e.g. DiGregorio and Shane (2003) claim that geographic location of universities influences USO activity because some economic, legal and cultural environments are more supportive of USOs than others. The networking capability of a USO has been shown to impact upon its performance Walter et al. (2006) USO activity does vary significantly across countries due to different attitudes e.g. Wright *et al.* (2002) found that the UK was significantly more productive than the US and Canada at USO creation in terms of numbers of USOs created per dollar of research funding, but significantly less successful in licensing to non-USOs. Again, this is an area that can be explored in comparing USOs from the West Midlands to other parts of the UK and overseas.

Shane (2004) states that four factors influence the level of USO activity in a location: access to capital to develop proof of concept and prototypes to attract private sector investors; property rights that reside with the university rather than the entrepreneur to minimise creating an anti-entrepreneurial culture, creates expertise at the university in company formation, spreads risk across a pool of USOs associated with the university and a range of technologies; less rigid labour markets to allow inventors ability to generate resources they need, take leave to start companies and increased mobility between universities and industry allowing flow of commercial knowledge to universities and areas where USOs are common already given the existence of managers, customers and suppliers. The financial performance of USOs will also be impacted (Sternberg, 2014).

It is also noticeable that certain regions in the UK e.g. the 'Golden Triangle' of Oxford, Cambridge and London universities appear to have achieved financial success from technology commercialisation, some of which may be attributed to the attraction of the region in which to start a business, including the existing infrastructure (Holi *et al*., 2007; Lawton Smith *et al*., 2014). Results from the current study will therefore be of interest to compare against such regions, as the West Midlands does not have such a strong reputation for successful hi-tech or start-up industries.

Harrison and Leitch (2010) note that USOs have achieved primary focus within the background of regional economic development by universities as they tend to locate close to their parent university and hence job and wealth creation remains local. They contrast this with technology transfer from a university to a large corporation where the benefit often transfers out of the local region due to a lack of absorptive capacity in the regional economic infrastructure (Steffensen *et al.*, 2000). The creation and growth of USOs can provide employment for university graduates and contribute to university revenues. Etzkowitz *et al.* (2000) find that the focus on USOs has been pronounced in the UK in response to a reduction in financial support for universities from central government with a shift from a grant to an exchange economy in higher education. Contract research and licensing have thus been important sources of revenue as the USO route requires more uncertain returns on investment over a longer period (Downes and Eadie, 1998). However, Harrison and Leitch (2010) note that, in the UK (Higher Education Funding Council 2007), income from the sale of shares in USOs accounted for less than one third of all income from the exploitation of protected IP, and was insignificant compared to other sources of income including contract research, consultancy and continuing professional development courses, accounting nationally for under 1% of total revenues, a trend that continued with just over 1% recorded for 2014/15.

2.6.2 Institutional aspects

A separate branch of the USO literature focusses on the difference in numbers and quality of USOs generated between universities. While this is not directly connected to the financial performance of USOs, it will still be an interesting angle to explore given that a range of different types of universities will be considered within the West Midlands region, and a potential area of study is to see whether universities that generate larger numbers of USOs correspond to those with the most successful USOs. A brief overview of the existing literature in this area is given below, with a focus on the individual university and the wider economic region in which it sits.

Shane (2004) notes that the number of USOs generated by a university does not necessarily correlate with the amount of technological inventions arising from the institution, an example from his study being that Harvard University produces almost no USOs despite a generating a large number of inventions, while Carnegie Mellon University produces a large number given its technological production. He identifies three key factors which appear to explain these variations: university policies, technology licensing office expertise and university goals and culture. Other studies have shown similar results e.g. Pressman (2002) noted that 36% of US academic institutions did not generate any USOs at all. Wright *et al*. (2002) found that 25% of UK universities generated no USOs while Charles and Conway (2001) showed that 24 UK

universities accounted for 75% of USOs in 2000. Tornatzky *et al*. (1997) showed that the number of USOs generated by a university is not a function of the amount of technology created by comparing the number of licenses disclosed to number of USOs for a number of US universities; no correlation was found.

University policies that tend to increase USO formation (Rasmussen and Borch, 2010; Shane, 2004) include allowing exclusive licensing to encourage entrepreneurs to bear the risk of development and financing, taking equity stakes in USOs to add legitimacy and reduce inventors' need to find funding, offering leave to academics to found USOs, providing incubation facilities, allocating lower royalties to inventors to encourage USOs rather than licences and providing access to pre-seed capital. The characteristics of the university technology licensing office also tend to increase USO numbers with provision of more resources, licensing officers with more experience of company formation and provision of access to a network of investors, managers and advisers. Other factors leading to more USOs include providing an entrepreneurial university culture, provision of entrepreneurial role models, the prestige of the university which facilitates resource acquisition under conditions of uncertainty and information asymmetry and provision of more industry funding which is better able to identify commercial applications and provide inventors with the skills to work with the private sector.

The relationship between a university and a USO is complex and will vary depending upon the nature of the USO, as discussed in the previous section, as well as the university itself. Di Gregorio and Shane (2003) consider that explaining variation in start-up activity is important for at least four reasons:

- University inventions are an important source of knowledge spill-overs and understanding the spill-over mechanism is important to understand technology creation and economic growth
- USOs tend to locate close to the university making them valuable entities for local economic development
- Successful USOs can generate wealth through IPOs for the university
- University entrepreneurs make different decisions from non-entrepreneurs, leading USO creation to generate important questions about university policies towards research, teaching and knowledge disclosure

In an important study in this area, Mustar *et al.* (2008) identify three models by which public research organisations (PROs), which include universities, organise their spin-off activities:

- Low selective model
- Incubator model
- Supportive model

The low selective model fits closely with the model of an entrepreneurial university (Etzkowitz, 2004) to stimulate as many entrepreneurial ventures as possible. Entrepreneurs do not need to be academic staff or use technology developed at the university, and are awarded small amounts of money and office space. Most spin-offs fit the lifestyle profile, as discussed in the typology section above. The incubator model has attracted much more attention from policy makers and is highly selective in which projects it chooses to support, focussing on VC-backed

ventures. TTOs set up at universities devote significant time, setting up the necessary IP structures, search for management teams and for VC funding. The supportive model requires a formal transfer of technology from university to USO, but is less selective than the incubator model in which USOs it supports. USOs best fit the prospector model with more ambition than a lifestyle company to grow, but not yet ready for VC funding.

Mustar *et al.* (2008) note that a university may require all three models to support their USOs, but TTOs are typically structured just to follow one. In a slight variation on this classification, Leung and Mathews (2011) identify three different examples of university involvement in USOs:

1. Minimalist approach – university offers administrative support to academic staff with proven technology that has been licensed. It takes a small equity stake in the USO in exchange for the transfer of IP rights
2. Maximalist approach – university actively seeks out prospective new ventures and investors driving the innovation speed and taking a higher equity stake and a stronger role in future growth of the USO
3. Confucian 'Middle Way' – university plays an active role in the launch of the USO seeking investors or a JV partner, but then adopts a passive role allowing the USO to develop its own strategy and aims to secure a relatively early exit and transfer IP to the USO

The effectiveness of university participation in USOs has been debated with most scholars finding high involvement is beneficial for USOs while others find it can lead to dependency (Rothermael *et al.*, 2007). They also note conflicting opinions over the nature of the founding team with some highlighting universities successful in creating USOs having favourable attitudes towards surrogate entrepreneurs (Franklin *et al.*, 2001), while others claim that coaching inventors leads to better performance (Clarysse and Moray, 2004). The parent university can also influence the USO's ability to obtain funding (Soetanto and Geenhuizen, 2015).

As already noted, USOs are not the only form of commercialisation of university knowledge. Minshall and Wicksteed (2005) identify that some universities generate considerably more start-ups (companies where the university has no claim on the IP) than USOs; the ratio will depend on relevant university policies, resource allocation and the overall culture in relation to enterprise. As a result, they propose two key conclusions:

- The number of USOs should not be interpreted as a free-standing indicator of the relevance of the university's research to the commercial world
- It should not be used uncritically as an indicator of the level of entrepreneurial enthusiasm amongst staff and other researchers

The significance of these findings for this study is that the number and type of USO may be influenced simply by the identity of the parent university. This will need to be taken into consideration when comparing results from universities within the region. It may also be possible to propose a model for the universities' different attitudes towards technology transfer based on the financial performance of their USOs, although any such prediction should be made with caution.

2.7 Conclusion

The current academic literature on USOs is growing and wide-ranging, with many different aspects that will impact upon this study that seeks to examine the financial performance of USOs within a region of the UK.

USOs represent an important part of the field of university entrepreneurship and some of the key concepts within this field have been defined. It can be seen that universities have, in recent years, been encouraged by policy makers, including national governments, to undertake entrepreneurship-related activities in addition to their traditional teaching and research. Such encouragement directly impacts this study as the number of USOs in existence increased rapidly from the year 2000.

The literature on USOs highlights the difficulties in obtaining a standard definition of a USO over a period of many years, which will impact this study in that a clear definition must be chosen to allow effective analysis of results and comparisons with previous studies. In addition, the literature highlights the heterogeneity of USOs with a wide range of properties displayed, and attempts to categorise them into a sensible typology. On first principles, studies of the financial performance of a number of USOs would be expected to show a wide range of results, an issue that must be kept under consideration when analysing the results of this study.

Finally, the regional and institutional impacts upon university entrepreneurship and USOs have been briefly considered. The current study is unusual in the literature in that it considers USOs from a single, post-industrial region away from the elite UK universities, and regional aspects may have an influence on the financial performance measures seen. In a similar vein, the institutional effect of the universities being studied may have a significant impact upon results obtained as a consequence of their attitude towards entrepreneurship in general and USOs in particular.

Chapter 3: Theoretical frameworks and performance metrics

This chapter firstly considers the issue of performance metrics, and in order to answer the overarching research question of Chapter 1, namely 'have USOs generated by West Midlands universities been successful in terms of financial performance?', it attempts to ascertain the most suitable performance metrics to analyse the financial performance of USOs at a company level. It then briefly reviews financial performance studies of USOs undertaken to date in the academic literature and examines the performance metrics used, identifying those that will be of value for the current work. Finally, it considers the relationships between such metrics, and attempts to build a performance model that can be used both now and in future work.

In order to provide an overall theoretical framework within which to assess the chosen metrics, the chapter then identifies potential theoretical frameworks within which USO performance can be assessed by reviewing those in the existing literature, and evaluates them as to their effectiveness for use in this work, before selecting the most appropriate.

3.1 Performance metrics - background and importance

The next section of the chapter considers in some depth the most effective performance metrics to be used in this work to analyse and conclude on the financial performance of USOs. In the context of economic development through knowledge transfer in a science and innovation knowledge-based economy, which includes technology transfer from universities, it is widely acknowledged that there needs to be consensus about the metrics used to measure the performance of technology transfer from universities. Measurement of both quality and quantity of transfer (Library House, 2008) are necessary to enable effective analysis to be undertaken. USOs form an important part of this technology transfer process, and their financial performance at a company level needs to be considered alongside the wider performance of the parent university in this field to give a complete picture. This is necessary both from a policy perspective as well as enabling effective assessments to be made of existing studies.

Various metrics in the area of measuring university technology transfer have been used to date. In the US, the AUTM (Association of University Technology Managers) measures annually the revenues obtained by universities from their intellectual property, although other studies have attempted to use a wider range of measures both financial and non-financial to give a fuller picture. In the UK, one of the most significant studies to date in this field is that of Library House

(2008), which was commissioned by UNICO (a technology transfer association) to build a coherent framework of metrics that could be used to both measure absolute performance and to benchmark performance between universities on an international basis, with USOs forming a part of this exercise. The commission exercise recognised the lack of an existing study on performance metrics and sought to address this gap, and other studies in the wider literature have noted the difficulty in obtaining a rigorous measure of performance e.g. Siegel and Wright (2015).

3.1.1 Views of university stakeholders on performance metrics

In the study undertaken by Library House (2008), within the wider context of measuring UK university technology transfer, potential financial performance metrics were initially generated through discussion with three key groups of university stakeholders: research funders, senior university management and the business community, reflecting the policy focus of the study. In the specific case of USOs, the following metrics were identified:

Stakeholder	Measures of quantity	Measures of quality
Research funders	External investment raised Revenues generated Market value at flotation	n/a
Business community	Number of USOs formed External investment raised Revenues generated Flotation/exit value	Survival rate/viability Growth rate Customer feedback
Senior university management	Revenues generated External investment raised	Survival rate/viability

Table 3.1 Stakeholder views on performance metrics - Library House (2008)

There is a significant degree of overlap between the metrics suggested despite the different backgrounds and perspectives of the stakeholders, which gives confidence that the metrics proposed are fit for purpose. Interestingly, it should be noted that the business community did not propose USOs at all as a mechanism of knowledge transfer for a university, although the reasons for this were not investigated further, but this finding may cast doubt at least on the perceived significance of USOs amongst policy makers and governments as a means for commercialising university knowledge.

In order to aid international comparison, the survey also undertook a similar exercise in identifying performance metrics by contacting senior technology transfer personnel at a number of US universities, on the basis that the US is generally seen as the world leader in technology transfer from universities. In terms of USOs, the following metrics were proposed from a US perspective (the UK findings across all stakeholders from above are shown again to aid comparison):

	Measures of quantity	Measures of quality
US universities	Number of USOs formed	Investor satisfaction

	Survival rate Amount of external investment raised Quality of investors Number of USOs that are geographically close to the university	Survival rate Amount of external investment raised
UK universities	Number of USOs formed External investment raised Revenues generated Flotation/exit value	Survival rate Viability Growth rate Customer feedback

Table 3.2 Measures suggested by TTO personnel - Library House (2008)

In general, the proposed metrics from the two countries are very similar. One interesting quantity metric proposed by the US stakeholders only is the number of USOs geographically close to the university, which may be a consequence of the different ways in which USOs obtain significant parts of their funding: by national research councils in the UK i.e. not region-specific, but by local state governments in the US. The US stakeholders also proposed the metric of amount of external investment raised as both a measure of quantity and quality, given that external investors offer a form of 'peer review' in assessing and then investing in USOs, reflecting their quality, a theme echoed in parts of the UK literature (Lambert, 2003).

3.1.2 Wider USO performance metrics - literature review

Apart from the Library House report, there is a small but growing academic literature assessing the financial performance of USOs at a company level. Rasmussen *et al.* (2012) undertook an extensive literature review of the academic work in this area on entrepreneurial firms including USOs. One of their research questions was 'what are the strengths and weaknesses of the different methodologies and indicators used to measure the impacts of SBEFs (science-based entrepreneurial firms)?' They produced the following table which includes only those studies identified which utilised financial performance measures:

Author(s)	**Which measures/indicators of impact or performance is used?**	**Key indicators**
Chrisman *et al.*, 1995	Impact measured as venture creation and employment growth	Economic impact (technology transfer)
Wallmark, 1997	Measure impact in terms of employment	Employment
Shane and Stuart, 2002	Analyses three dimensions of performance: the ability to attract venture capital, experience IPOs and failing, Also considers the time it takes to achieve each of these outcomes.	Resource acquisition, financial, survival
Nerkar and Shane, 2003	Performance measured as firm survival (acquired firms	Firm survival

	included). Authors test several factors that influence survival and success of a new start-up firm.	
Perez and Sanchez, 2003	Impact measured as number of employees. Explores technology transfer by looking at networking activities.	Technology transfer
Ensley and Hmieleski, 2005	Performance measured as net cash flow and revenue growth. University-based start-ups are found to be significantly lower performing in terms of net cash flow and revenue growth than independent new ventures	Financial firm performance
Garnsey and Heffernan, 2005	Impact measured as survival, employment and turnover. Discusses impact from clustering at regional level.	Survival, employment, financial
Leitch and Harrison, 2005	Discussing impact measures such as survival rate, turnover, employment and second order spin-offs	Regional development
Lindelof and Lofsten, 2005	Performance measured a sales growth and profitability. There is no evidence that USOs exhibit slower growth (sales) than CSOs – they are also equally profitable.	Financial
Moray and Clarysse, 2005	Performance measured as financial measures and employment growth. The research institution significantly impacts the starting configuration of its USOs.	Financial, employment growth
Lawton Smith and Ho, 2006	Impact measured as employment, turnover, market capitalisation and patenting and licensing activity. Discusses the contribution to the economy.	Employment, financial, innovation, regional impact
Walter *et al.*, 2006	Performance measured as sales growth, sales per employee, profit attainment, perceived customer relationship quality, realised	Financial

	competitive advantages and long-term survival	
Buenstorf, 2007	Time period of presence in the laser industry is taken as a measure of firm performance	Firm survival
Clarysse *et al.*, 2007	Start-up capital raised within 18 months of start-up. Average capital increase (total capital divided by firm age)	Obtaining external financing
Toole and Czarnitzki, 2007 and 2009	Performance measured as completing SBIR program, patents granted and follow up private venture capital backing	Start-up process, attract VC funding
Valentin *et al.*, 2007	Performance measured as financial performance, number of patents	Financial, innovation
Zahra *et al.*, 2007	Performance measured as productivity, profitability (ROA) and revenue growth	Financial
Soetanto and Van Geenhuizen, 2009 and 2010	Performance measured as annual average job growth	Employment growth
Zhang, 2009	Performance measured as firm survival	Survival
Bonardo *et al.*, 2010	Performance measured as probability of being acquired after IPO	Venture acquisition
Colombo *et al.*, 2010	Performance measured as growth in number of employees The contribution of university research to the growth of academic start-ups (number of employees)	Employment growth
Harrison and Leitch, 2010	Impact measured as employment and turnover. Impact on the entrepreneurial system is discussed.	Employment, financial
Vincett, 2010	Impact is measured as the present value of past and future sales. Discusses the contribution to Gross Domestic Product.	Financial
Munari and Toschi, 2011	Performance measured as firm's ability to attract VC funding. Venture capitalists do not have a bias against	Attract VC funding

	investment in academic spin-offs.	
Rasmussen *et al.*, 2011	Performance defined as reaching the credibility threshold (adding new team members beyond the original inventor(s) and early stage investment from a private sector investor).	Process of venture start-up

Table 3.3 Performance metrics taken from Rasmussen *et al.* (2012)

In reviewing the relevant literature, Rasmussen *et al.* (2012) note that studying firm performance during the early start-up process is challenging because it is difficult to identify samples of firms at an early stage of development, and USOs often have long development paths before they grow and become profitable, making it difficult to effectively use growth-based performance measures. Measures such as gaining external equity investment and additional team members are thus useful in studying the early stages of a firm as it seeks to overcome the credibility threshold. As a consequence, Rasmussen *et al.* (2012) note that to investigate the long term effect of start-up conditions there is a need for longitudinal datasets over long periods of time. This observation applies equally to financial performance studies. They further note that creating datasets by using historical data is labour intensive and restricted to issues covered by historical documentation, which is the driving force behind the current work. One example of a long-term study in the literature is that of Buenstorf (2007) who examined the evolution of the German laser industry using historical data from various sources over forty years. Rasmussen *et al.* (2012) consider, however, that the recent increase in studies on USOs will allow more follow-up studies on existing datasets. It should also be noted that there are a number of common performance measures between the studies of Rasmussen *et al.* (2012) and Library House (2008), which gives a valuable insight for the current work as it seeks to identify the most effective performance metrics to answer the overarching research question.

3.2 Difficulties in measuring financial performance of USOs

There have been relatively few studies of the financial performance of USOs at a company level to date in the UK and elsewhere (Wennberg *et al.*, 2011). At first glance this may be surprising as there are a large number of USOs which have been created over a significant length of time providing a potentially suitable dataset. In addition, many countries spend significant sums of money targeting university based entrepreneurship (Wright *et al*., 2008) and as a policy this only makes sense if this kind of entrepreneurship is an effective way of establishing companies with high growth potential. However, attempts to conduct studies meet a number of practical difficulties, which have led to the repeated observation that there is a lack of financial data relevant to USOs of a sufficiently high standard (Zhang, 2009). Rasmussen *et al.* (2012) note that most studies to date on impact of USOs use simple measures often selected on the basis of data availability. These findings will inform the choice of research methodology for the current work.

Throughout the literature to date, a number of themes on the difficulty of obtaining USO financial performance data and conducting meaningful analysis therewith have emerged. Firstly, as noted previously, there is no consistent definition in the academic literature of a USO (Zahra

et al., 2007). For example, in considering the four different definitions of a USO under the HEFCE classification as noted in Chapter 2, clearly these are four very different types of entity and constructing a dataset for any one category would require very different methods from the others. Any attempt to compare financial performance across the categories, or even to be sure that all relevant companies have been captured, is therefore extremely challenging. Where a population of USOs is obtained, it is impossible without detailed analysis, or using strict definitional criteria, to be sure which kind of USOs are present, which makes any attempt to compare results to similar studies fraught with difficulty.

Secondly, it is difficult to verify the total population of USOs associated with a university, which leads to the danger of survivor bias (Shane and Stuart, 2002). While universities and their associated TTOs maintain data, it may be incomplete, especially in respect of older USOs or USOs that have failed many years previously. There may also be vested interests to take less care in recording this latter category. While commercial databases do exist e.g. Spinouts UK which is maintained by Young Company Finance and used in this work, the data contained therein is only as good as its source, which often includes TTOs, and needs to be verified thoroughly.

Those performance studies that have been carried out to date have also been prone to use measures that are not necessarily the most appropriate in assessing the financial performance of USOs, and may be based more on the availability of data. While measures such as sales and employee growth are relatively easy to establish, they may not be the most appropriate for young companies such as USOs as they can very easily give distorted results as the quantity being measured is starting from a nil or very low base position. Measures which seek to determine the value of USOs, for example the amounts of finance raised from third parties, are often much more useful but data is very hard to come by. This is due to the fact that such deals are often kept confidential in terms of numbers and that older deals suffer from a lack of data still available in the public domain.

A further limitation on obtaining financial data for the UK USOs is the reduction in data availability for such companies on public record over recent years. For some years in the UK, small companies have been able to file abbreviated sets of accounts at Companies' House, which do not require disclosure of a wide range of information, including both turnover and employee numbers. Given that this is the only publicly available source of company financial data for private companies, it is now almost impossible to collect such data from a third party source independent of the company itself which reduces the objectivity of any analysis. Given their size, almost all USOs will file abbreviated accounts to avoid the time and cost of making more detailed disclosures. Such issues have already been noted in performance studies (Lawton Smith and Ho, 2006), and the importance of obtaining data from sources outside a university environment has been noted (Wennberg *et al.*, 2011).

These collected difficulties were noted in the Library House (2008) survey above, which identified a number of problems in collating suitable metrics for reasons already discussed at some length. From a quantity measure perspective, the survey had difficulty in defining USOs, a perennial problem in this area as already discussed. In particular, the difference between a spin off and a start-up company and how to be sure that a university was counting in such a way as to meet the definitions and allow effective comparison between institutions caused problems. In addition, on the quality front, the lack of data in the public domain on metrics such as growth rates was noted.

3.3 Classification of USO financial performance measures

A number of attempts have been made to analyse USO performance over the years as already noted (Rasmussen *et al.*, 2012). These may conveniently be grouped by nature of performance measure investigated and the key measures are summarised as follows (Jelfs, 2016):

3.3.1 Descriptive performance measures

Measures of absolute performance used in studies of USOs to date include company turnover (Lawton Smith and Ho, 2006), the number of company employees (Harrison and Leitch, 2010), number of patents granted to the company (Lindholm Dahlstrand, 1997) and net cash flow (Ensley and Hmielski, 2005). Amongst these measures, employment or job creation is a popular performance measure, particularly of interest to policy makers in regional and national government and their associated development agencies and may be particularly relevant for studies considering the impact of USOs at regional level.

While these measures give an indication as to the scale of activity of the USO, and are likely to be fairly easy for which to collect data, they only provide a snapshot of performance (Lawton Smith and Ho, 2006). They also do not address the issue of whether USOs are performing effectively in relation to other start-up companies (Zahra *et al.*, 2007) or to the level of investment made in them. For example, the number of patents held by a company may not necessarily reflect its success and growth (Zahra *et al.*, 2007). Grimaldi *et al.* (2011) note the 'need to move beyond count measures…in order to estimate the value and quality of that activity'.

In addition, metrics such as Return on Capital Employed (ROCE), although a common financial performance measure for more established companies, are difficult to use for USOs. Most USOs are attempting to commercialise novel technology and are pre-revenue, relying on external investors to fund their development programmes. Their income statements would therefore show a deficit each year, which would give a negative ROCE and not allow for meaningful analysis or comparisons between USOs. In addition, the lack of publicly available data concerning income and expenditure of small companies in the UK, and the lack of public disclosure of balance sheet items as noted above in the discussion over Companies' House reporting, means that obtaining data needed to calculate ratios such as ROCE are all but impossible to obtain from an objective source, which is a key requirement of this work.

3.3.2 Growth-based performance measures

Performance measurement studies based on the growth in a variety of variables have been widely used in the literature. Growth has been identified as the most appropriate measure of performance for new ventures, (which are often loss-making), which encompasses many USOs (Clarysse *et al.*, 2011). The variables used follow closely from the previous section.

Growth in turnover (Wennberg *et al.*, 2011; Zahra *et al.*, 2007; Clarysse *et al.*, 2011) and in employee numbers (Wennberg *et al.*, 2011; Lindholm Dahlstrand, 1997; Clarysse *et al.*, 2007) are the two most popular measures of performance. Such measures have the advantage over

absolute performance measures of providing a more dynamic picture of the company over a period of time and allowing for more meaningful comparisons between USOs. Woo *et al.* (1992) note that sales growth has been used extensively as a measure of performance in strategic management research. Clarysse *et al.* (2011) note that sales growth is a preferred measure for new ventures as it is relatively accessible, applies to almost all companies and is relatively insensitive to capital intensity and degree of integration (Delmar *et al.*, 2003).

Chandler and Hanks (1993) note that employee growth is a good indicator of the speed at which a new venture can grow; in the case of USOs, assets and employment often grow before sales are generated as the underlying technology is developed. Delmar *et al.* (2003) consider employee growth a more direct indicator of performance than sales growth for certain companies, a view shared by other resource-based scholars (Clarysse *et al.*, 2011). Davila *et al.* (2003) note that companies may reach an IPO with considerable value before any sales are generated. These views are in interesting contrast to Shepherd and Wiklund (2009) who found that sales growth was vastly the most popular measure in the growth literature.

As with descriptive performance measures, there are still a number of limitations with these growth-based performance methods (Tietz, 2013), as well as some inconsistent results. Firstly, they say nothing about the true financial value of the company; a company may have developed very valuable technology but not yet achieved any sales. Employment data can be misleading or difficult to gather as many USOs will typically use self-employed consultants rather than employees in the early days to avoid expensive costs of employment such as employer's National Insurance, and allow more flexibility to hire only when work is required. In addition, data can be distorted given that the USO will typically be starting from nil or a very low base value on the growth measure. There is also a particular problem in the UK and other countries with the obtaining of growth data as discussed above. Finally, Shepherd and Wiklund (2009) note that there is a lack of correlation between different measures of growth, although the reasons for this are not entirely clear. As a result, it is usual to analyse at least two different measures.

3.3.3 Survival measurements

A third category of financial performance measurement of USOs concerns the length of time that the company survives or is actively undertaking some form of business activity. On first principles a company that does not survive is one that is unsuccessful. It is widely recognised that most companies, including USOs, that fail do so within their first few years following the commencement of activity. Studies which have included length of survival as a USO performance measurement include Wennberg *et al.* (2011), Oskarsson and Schläpfer (2008), Zhang (2009) and Criaco *et al*. (2013). Oskarsson and Schläpfer (2008) state that survival is the most popular financial performance measure in the USO literature. They note that this model is a longstanding one in the more general venture capital literature, and has been further refined in the literature dealing with venture capital investment performance to consider four possible options for portfolio investments: initial public offering of shares, trade sale, still in portfolio and failure. These categories are directly equivalent to those in the USO literature.

It is relatively widely noted across studies from a range of countries and universities that USOs tend to survive for longer than other start-up companies (Shane, 2004; Tietz, 2013). Zhang (2009) provides three possible explanations for this particular phenomenon: academic

entrepreneurs have higher opportunity costs than non-academics (i.e. more to lose if the USO fails), a tacit technology advantage arising from the USO's university origins given the high quality nature of research performed at the institution, or finally the benefits of incubatory services provided by the university. A number of these perceived advantages are open to debate. Other explanations for this phenomenon include USOs remaining small and highly innovative developing technology exploited by others (Dahlstrand, 1997b) or Nerkar and Shane's (2003) view that firms exploiting more radical technologies and broad patent scopes (both criteria often met by product-oriented USOs) may survive longer. It should, however, be noted that a number of commentators identify less positive reasons for this phenomenon, an example being de Cleyn (2011) who notes that some USOs may be kept artificially alive by subsidies.

Oskarsson and Schläpfer (2008) find that, from their review of a number of survival studies, although they cover different timespans and economic conditions, the stated USO survival rates are in the region of 70-90% and consistently higher than the survival rates of non-USOs across a range of countries and universities. Other studies give results in line with this general theme. Lindholm Dahlstrand (1997b) found that 89% of 240 Chalmers University USOs between 1960 and 1993 survive at the latter date with an annual failure rate of only 1.4%. Di Gregorio and Shane (2003) found 70% of 2,578 US USOs founded between 1980 and 1998 survived at the latter date.

Survival of USOs is a popular financial performance measure either considered alone or in combination with others, and may be a more appropriate measure than metrics based ono profitability (Criaco *et al*., 2013). Rasmussen *et al.* (2012) consider survival to be a simple measure with data easily available, but note that surviving USOs may stall in growth terms and lead to limited impacts. The simple proposition that a surviving company implies a successful financial performance is therefore not necessarily true. They consider it a shallow measure that reveals little about the development pattern of surviving firms. In addition, they note that the measure may be biased if the destinies of the non-surviving firms is not known. Rasmussen *et al.* (2012) further note that the process of USO creation is complex and dynamic and studying it is challenging as a result. Most studies to date are derived from data relating to successful companies and hence suffer from survival biases. Few studies in the existing literature have access to data that can separate USOs that fail from those that are bought or merged. These are significant issues for the performance metric of survival which this study will seek to address.

3.3.4 Valuation and external investment measurements

The final group of financial performance metrics for USOs is concerned with looking at the value created by the company for its shareholders. The ultimate goal of any USO is to create financial value which can potentially be realised for its equity holders, in ways such as a public stock market flotation or other sale of shares. The large US companies that have achieved this in the past from university origins, e.g. Genentech (Wennberg *et al.*, 2011) and Cisco (Zhang, 2009), have significantly contributed towards government interest in the policy of creating USOs throughout the world.

Woo *et al.* (1992) consider that market-based measures reflecting the shareholder value of a company may be the best measure of the company's performance. They note that share prices are the value of the earnings over the lifetime of the company discounted for risk to

shareholders and should, in theory, reflect both current and future performance. The difference between market and book value of a company has been seen as a measure of the ability of the company's strategy to deliver required returns to investors, a measure of long term wealth creation (Peters and Waterman, 1982) and evaluating overall performance, benefits of specific competitive actions and different corporate restructuring alternatives (Fruhan, 1979). Clearly such measures are difficult to apply to USOs that are not listed on a public stock exchange and Bonardo *et al.* (2011) note that listed USOs may be different to 'typical' USOs.

One way to obtain a measurement of a USO's value is simply to look at the company's market capitalisation e.g. Lawton Smith and Ho (2006). This is clearly very difficult to apply to companies that are not listed on a stock exchange and, given the volatility of stock markets, data collected may be quickly out of date. Valuations of privately-held companies may be carried out, often using data from comparable listed companies, but again this is a difficult and specialist area, and one in which experts frequently significantly disagree.

Some interesting variations on this theme of company valuation were explored by Zhang (2009) who considered, among other performance measures, the amounts of investment a USO raises from third party venture capitalists and the percentage of companies who ever made an IPO of shares, an event described as 'a crowning achievement for the parent university' by Bonardo *et al.* (2011). The former measure had already been highlighted by Lambert (2003) who considered this a good measure of the quality of a USO given the stringent due diligence performed by private equity firms before making any investments. Lambert (2003) noted that USO creation in the UK had been largely driven by government-funded University Challenge Funds with only one third of new USOs in 2002 securing capital from private equity. Rasmussen *et al.* (2012) note that most USO performance studies rely on proxy measures rather than direct performance measures; as USOs often need significant financing to develop their product or service, obtaining external financing is considered a useful measure, given that external financiers will independently assess the USO's potential for success and establish a value to guide their investment.

The major study to date on the subject of valuation returns generated by USOs is that by Oskarsson and Schläpfer (2008). They undertook a performance study of USOs from ETH Zurich employing a number of venture capital valuation methods to calculate returns on equity, a technique that has been explored before in the venture capital literature although not specifically in the context of USOs. The general premise is that venture capital investments have historically shown high average returns and high risk, with wide variations in return observed. However, it should be noted that metrics such as internal rate of return are very difficult to measure for small, early-stage unlisted companies, typically involving estimations and use of comparables. In addition, basing valuation on financing and imputing valuations is fraught with difficulty, especially given the rate of failure amongst start-up companies (Nadeau, 2011). Oskarsson and Schläpfer (2008) actually put forward the thesis that academic enterprises perform better than other start-up companies. De Coster and Butler (2005) show that USOs typically have a better protected competitive position and better satisfy market demand. Other factors mentioned in the literature include access to a more extensive support system and the value of a university brand.

As noted above in the Library House (2008) work, obtaining venture capital investment is seen as a positive performance metric and has been explored in a number of studies e.g. Soetanto and Geenhuizen (2015). Shane and Stuart (2002) show that the percentage of successful exits

through an IPO of shares is strongly correlated with the amount of VC funding obtained. Wright *et al.* (2006) state that VCs are reluctant to fund USOs at seed/start-up stage due principally to their concerns over the lack of experience in the management team, but that USOs are significantly more likely, despite this, to obtain venture backing than the average small business. USOs do, however, tend to get funding at a later stage resulting in a 'funding gap'. However, access to venture financing is a key determinant of growth and value generation for new technology-based USOs and those that fail to attract VC funding in early years are unlikely to do so in future.

3.3.5 Metrics chosen for this study

It can be seen from the above that two performance metrics in particular stand out as providing good evidence for the successful financial performance or otherwise of a USO at a company level, and are at least possible to evaluate given the current public availability of data in the UK. These are (i) survival and (ii) the attraction of external investment. Both metrics are identified as important in the Library House (2008) study, as well as the wider evaluation of the literature by Rasmussen *et al.* (2012), providing comfort with this finding, although not all recent studies have used them e.g. Sternberg (2014). These two metrics will form the core of this study in terms of performance data collection and analysis. The ability or otherwise of USOs to reach an IPO or an exit for investors will also form a complementary metric, representing a specific scenario in obtaining external investment, as again the data is available and the metric is a good one for the evaluation of successful financial performance for a USO.

Returns on equity or internal rates of return, though commonly used in the venture capital valuation literature, as well as in practice by investors and fund managers (Nadeau, 2011), will not be used here, given the restricted nature but extremely accurate nature of the data to be collected. Measures such as ROCE are not appropriate given the nature of the unit of analysis i.e. the USO, many of which show accounting losses given their pre-revenue status as they seek to commercialise technology.

This 'triumvirate' of USO financial performance metrics can be represented below as a model in diagrammatic form:

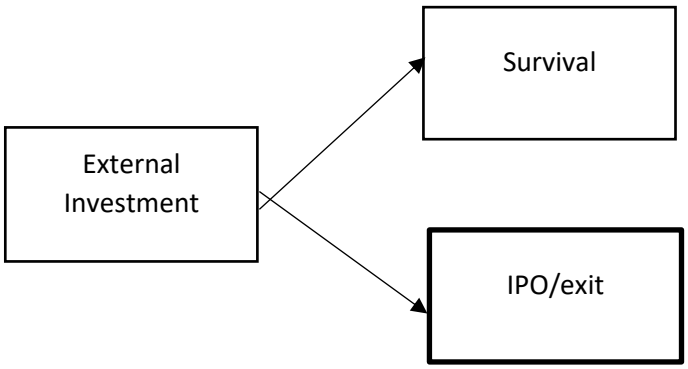


Figure 3.1 'Triumvirate' of performance metrics (author diagram)

As can be seen, the attraction of external investment by a USO, while a key financial performance metric in its own right, may also on first principles have an impact upon the survival or completion of an IPO or exit by reflecting the strength of the company and its attractiveness to investors. Subsequent sections of this chapter briefly review the literature on the relationship between attracting finance and subsequent financial performance. On first principles, a new company with more resources might be expected to survive for longer (Aspelund *et al*., 2005)

3.4 Literature review of USO financial performance studies - introduction

Following the selection of the performance metrics to be used in this work, this section introduces studies in the existing USO literature that also use these metrics, and against which results from the West Midlands can be compared.

3.4.1 Summary of existing studies

The key study in the literature to date of particular comparability with the current work is that of Oskarsson and Schläpfer (2008). This study looked at the financial performance of USOs generated by the Swiss Federal Institute of Technology Zurich (ETH Zurich), an institution which focusses on teaching and research into science and technology. Their population consisted of 130 USOs formed during the ten year period from 1998 to 2007. While their study also considers other performance measures such as USO employee numbers and an attempt to measure the return on equity arising on each USO through a calculation of equity value generated (a measure that requires a number of significant assumptions to be made and is likely to have produced dramatically lower results in the worldwide 'credit crunch' that immediately followed this period), metrics for which the current work cannot obtain independent data, survival and third party investment were two other metrics considered.

Oskarsson and Schläpfer's (2008) study is an empirical one reflecting the commercial finance background and viewpoint of the authors. As such, it does not consider the results in the light of any single theoretical framework, although its literature reviews are comprehensive in nature. This is a common theme amongst those academic works in the USO performance field, and is likely also to apply to the current study, given the broad policy-based nature of the overarching research question. It should also be noted that, in common with many other examples from the literature, their data collection relied significantly upon questionnaires sent to USOs that were still surviving, a research technique which this study will not replicate for the purposes of accuracy. In addition, their study compares and contrasts their findings with results of other works, which leads to some comfort with the current work that no further studies have occurred that have been omitted.

A brief summary of some of the other more significant studies against which the results from the current work may be compared and contrasted is given below, as well as an indication of whether survival, investment or IPO data is considered.

Shane (2004) is an early study of USOs by a researcher in the field from the US who collates data from a number of other studies covering different countries such as the Netherlands and Sweden. The study also contains data from a large sample size of USOs from the US. Survival results from all these studies were collated by Oskarsson and Schläpfer (2008) and will be compared against the results from this work. The Shane (2004) study is an important example of early work in the field which led to the widespread observation in the literature that USOs survive for significantly longer than other start-up companies. However, concerns about the accuracy and completeness of the data sets of USOs being compiled and used were one of the key motivations behind the undertaking of this work.

Clayman and Holbrook (2006) collected survival data from USOs generated by Canadian universities. A database of USOs was constructed from data provided by university-industry liaison offices (UILOs), and a USO was deemed to be inactive if it had no website and no reference could be found to it by a Google search. Again, there are significant concerns with the accuracy of the above methodology. The authors of this paper acknowledged that the UILO data was at risk of being out of date in respect of more recent USOs, and that the methodology used to determine activity is likely to be an understatement of survival in respect of USOs that have been absorbed by another company.

Leung and Mathews (2011) considered the survival of USOs from Hong Kong universities although the exact source of the population is not entirely clear, but TTOs from the relevant universities are likely to have been a significant source. The authors acknowledged that data could not be obtained from a number of USOs that were no longer in existence which places limits upon conclusions drawn from the findings.

Wennberg *et al.* (2011) considered a large population of USOs from Sweden. The USOs were identified in an unusual way, firstly by identifying all privately-incorporated companies in Sweden over a period of time in knowledge-intensive sectors. This data was then cross-checked with a database called LISA which is maintained by Statistics Sweden and contains annual data about all Swedish inhabitants including detailed information about education and employment, and where an individual transferred into entrepreneurship directly from employment in a university the company which they joined was designated a USO. This method clearly relies on an unusually detailed database the like of which is not available in the majority of other countries (including the UK), but does have the significant advantage of not simply relying on data supplied by a TTO. This paper is significant as it is one of the first to consider the methodology by which an accurate population of USOs can be drawn up from objective sources, and considers more than one source of data. It provides survival data for comparison with the current work.

Zhang (2009) used the VentureOne commercial database which provides data on venture capital investments into all companies in the US, but screened for USOs by only considering companies where one of the founders per the database had previously worked in a university. The author noted that this methodology ignores all USOs that do not attract VC funding as well as USOs where the founders' details were not recorded in the database. This makes comparability with other studies difficult, including the present work, but survival, investment and IPO data are provided.

Holi *et al.* (2007) considered a large population of UK USOs over a five year timescale and collected details of external investment, so on first principles this would be a very useful

comparison for the current work. Unfortunately, the detailed data could not be accessed as the publisher of the study, Library House, is no longer trading. Oskarsson and Schläpfer (2008) and Mueller (2010), who had access to the databases, allow some comparisons to be drawn.

Mueller (2010) in an unpublished PhD thesis considered USO financial performance from a Resource-Based View (RBV) theoretical perspective in line with other studies, a model mentioned briefly above, and also provided some details of external investment. The USO population was drawn solely from a single Library House database which again leads to queries over whether the population is complete and accurate.

Munari and Toschi (2010) identified a population of USOs in the UK by starting from a population of all MNT (micro- and nano-technology) companies active in 2004 from data supplied by the MNT Network, and identifying USOs within the sample by methods that are not entirely clear. The Venture Expert database was then consulted to see which of these USOs obtained funding as of December 2007. Again, the methodology used leads to concerns over the completeness and accuracy of the USO population as there is no auditable trail behind the initial population of USOs and commercial database are often incomplete so comparison with the current work must be made with great care. Detail of external investment attracted by USOs was provided by this study.

Minshall and Wicksteed (2005) provide some external investment data for a small number of UK USOs. This is one of the early studies in the field when concerns were starting to be raised about the reality of the financial performance of USOs. Three different classes of university were considered: universities with large research budgets (Oxford, Cambridge, Imperial and University College London), other large universities in major cities (Edinburgh, Newcastle and Southampton) and universities with much smaller research budgets, reflecting in part their lack of medical research activities, but each with a high proportion of research funds coming from UK industry (Cranfield, Loughborough, Strathclyde). This classification is interesting, although the sample is very small, and again the data was all obtained from the relevant university's TTO.

As can be seen, there are a wide range of methodologies used in the studies above for identifying populations of USOs, so care will need to be exercised when undertaking comparisons with data from the current work. Where significant discrepancies in results exist, the methodology used in the studies should be examined to see if any potential explanations can be obtained.

3.4.2 Results from existing studies

The tables below collate the results from the above studies for USO survival, third party financing and IPO/exit. Detailed analysis of these findings will be performed and discussed in a later chapter alongside the results from the current study.

3.4.2.1 Survival

The two tables below combine USO survival data from Oskarsson and Schläpfer (2008) and other studies in the literature, performed by both by country and university.

Country	Survival rate (%)	Period	Years	Sample size	Source
USA	68	1980-2000	21	3376	Shane (2004)
Canada	73	1995-2003	9	301	Clayman and Holbrook (2006)
Hong Kong (timed rate after 5 years)	79	1997-2004	8	56	Leung and Mathews (2006)
Netherlands	83	1984-1992	9	92	Shane (2004)
France	84	1984-1987	4	100	Mustar (1997)
Sweden	87	1960-1993	34	30	Shane (2004)
Northern Ireland	94	1984-1995	12	17	Shane (2004)
Sweden (timed rate after 2 years)	73	1994-2002	9	528	Wennberg *et al* (2011)
Sweden (timed rate after 5 years)	53	1994-2002	9	528	Wennberg *et al* (2011)
USA	94	1991-2001	11	655	Zhang (2009)

Table 3.4: USO Survival data by country (Oskarsson and Schläpfer, 2008)

University	Survival rate (%)	Period	Years	Sample size	Source
USA – MIT	80	1980-1996	17	134	Shane (2004)
Oxford	90	1950-2004	55	64	Lawton Smith and Ho (2006)
ETH Zurich	88	1998-2007	10	130	Oskarsson and Schläpfer (2008)

Table 3.5: USO Survival data by University (Oskarsson and Schläpfer, 2008)

3.4.2.2 External investment and IPO

The tables below compare data collected from previous studies, some of which were collated by Oskarsson and Schläpfer (2008), concerning the performance metrics of attraction of third party external funding by USOs and successful exits from USOs across a range of universities from different countries, although mostly from the UK. Table 3.7 simply shows the percentage of USOs that attracted external third party funding that were created at each academic institution. Table 3.8 shows the percentage of USOs that achieved a successful exit for its parent through a trade sale or IPO of its shares. In the same format as above, Table 3.9 shows the total amount of external funding secured by a university for all of its USOs, while Table 3.10 shows the amount of funding obtained by USOs that obtained any level of funding i.e. removing the distorting influence for a university of its USOs that did not achieve any external funding.

Oskarsson and Schläpfer's (2008) study on ETH Zurich was only able to obtain data on funding from 82 of its 130 USOs as a result of non-responses to their questionnaire, hence the smaller sample size in Table 3.9, although the authors did not consider that this fact distorted any of

their results or conclusions. Data in Table 3.10 for the other UK universities is not complete as the Holi *et al.* (2007) report can no longer be accessed, although enough relevant information was obtained from citations in Oskarsson and Schläpfer (2008) to enable a reasonable level of comparison with other studies.

University	**Total USOs**	**Number with external funding**	**% with external funding**	**Source**
ETH Zurich 1998 - 2007	130	34	26	Oskarsson and Schläpfer (2008)
10 UK universities 1998 - 2002	172	111	65	Minshall and Wicksteed (2005)
Cambridge, Oxford, Imperial College, University College London	99	71	72	
Edinburgh, Newcastle, Southampton	36	25	69	
Cranfield, Loughborough, Strathclyde	37	15	40	
20 UK universities 2001 - 2006	233	137	59	Holi *et al.* (2007)
Cambridge	30	20	67	
Oxford	24	18	75	
Imperial College	29	19	66	
University College London	9	6	67	
Edinburgh	26	15	58	
UK universities 1985 - 2007	123	42	34	Munari and Toschi (2010)
UK universities 1990 - 2007	125	78	62	Mueller (2010)

Table 3.6 Percentage of USOs attracting third party financing

University	**Total USOs**	**Trade sales**	**% trade sales**	**IPOs**	**% IPOs**	**Source**
ETH Zurich 1998 - 2007	130	8	6.2	1	0.8	Oskarsson and Schläpfer (2008)
US universities	655				7.6	Zhang (2009)

20 UK universities 2001 - 2006	233	8	3.4	5	2.1	Holi *et al.* (2007)
Cambridge	30	1	3.3	0	0	
Oxford	24	0	0	1	4.2	
Imperial College	29	1	3.4	1	3.4	
University College London	9	2	22.2	0	0	
Edinburgh	26	0	0	0	0	

Table 3.7 Percentage of USOs obtaining a trade sale or IPO

University	**Total USOs**	**Total funding (£'000)**	**Funding per USO (£'000)**	**Source**
ETH Zurich 1998 - 2007	82	153,855k CHF = 65,470	798	Oskarsson and Schläpfer (2008)
10 UK universities 1998 - 2002	172	494,446	2,874	Minshall and Wicksteed (2005)
Cambridge, Oxford, Imperial College, University College London	99	344,572	3,481	
Edinburgh, Newcastle, Southampton	36	121,806	3,384	
Cranfield, Loughborough, Strathclyde	37	28,068	759	

Table 3.8 Total third party external funding obtained by a university

University	**Total USOs**	**Total funding (£'000)**	**Funding per USO (£'000)**	**Source**
ETH Zurich 1998 - 2007	24	153,855k CHF = 65,470	6,411k CHF = 2,728	Oskarsson and Schläpfer (2008)
US universities	606		$23.55m = 13,853	Zhang (2009)
10 UK universities 1998 - 2002	111	494,446	4,454	Minshall and Wicksteed (2005)
Cambridge, Oxford, Imperial College,	71	344,572	4,853	

University College London				
Edinburgh, Newcastle, Southampton	25	121,806	4,872	
Cranfield, Loughborough, Strathclyde	15	28,068	1,871	
20 UK universities 2001 - 2006			2,300	Holi *et al.* (2007)
Cambridge			5,500	
University College London			4,300	
UK universities 1990 - 2007	78		19,754	Mueller (2010)

Table 3.9 Funding obtained per USO that attracted funding

In summary, although the number of studies potentially comparable to this work is small, there is sufficient data across the three performance metrics chosen to allow interesting comparisons to be made.

3.5 Impact of finance on USO performance

As noted above, an area for potential investigation of this study is the impact of obtaining external financing upon the survival and IPO/exit prospects of a USO. There are a number of studies in the literature which explore this relationship, and these are discussed briefly below.

The financing of new, technology-based companies has been explored previously in the literature, particularly that relating to venture capital financing. Many of the principles derived from these branches of the literature can be equally applied to USOs, which are usually formed to attempt to commercialise a newly developed technology discovered in a university setting. Shane (2004) notes that most newly-formed USOs need to develop their product or process from a technical perspective, as well as their potential market, which is likely to require significant external funding and will often be beyond the means of the academic entrepreneur to fund from their own resources.

In an important summary study of USO finance, Shane (2004) identifies four key issues relevant to the subject of USO financing which are discussed in more depth below, highlighting their potential relevance to the current study:

- The importance of capital acquisition for USOs

- The financing gap faced by many USOs and the importance of public sector funding in overcoming this gap and allowing USOs to develop
- Uncertainty and information asymmetry making capital acquisition difficult for USOs, and how investors and entrepreneurs cope with these problems
- The different sources of capital used to finance USOs

3.5.1. Importance of capital acquisition

Shane (2004) notes that USOs usually require significant amounts of capital to undertake both technical and market development. Shane and Stuart (2002) found that the average amount of capital raised by MIT USOs founded between 1980 and 1996 was $5.3 million while Aldrich (1999) noted that less than one per cent of all US start-ups raise more than $1m, highlighting the capital-intensive nature of USOs compared to other companies. Capital also provides USOs with a buffer against adverse conditions and events allowing consideration of alternative strategies and enhancing external perception of the USO. In addition, obtaining adequate capital may enhance the performance of USOs, with the greatest reason for abandoning setting up a USO being inability to obtain sufficient capital, and the amount of capital obtained by a USO has been shown to be positively associated with the likelihood of acquisition or IPO, and negatively associated with company failure (Shane and Stuart, 2002). This provides an early indication of the nature of the relationship between the three elements of the performance metrics 'triumvirate' of this work noted above, which will be tested to see if it applies for the West Midlands region.

3.5.2 Public sector and the financing gap

Shane (2004) notes that while the ability to raise private capital at the time of USO formation varies by institution (with more prestigious institutions more likely to do so), public sector finance is still valuable in attracting further private sector capital. This phenomenon has already been noted in the formation of UCFs by the UK government. The financing gap, where private investors are unwilling to provide funding to a USO at an early stage due to the levels of risk involved, is most severe for sectors outside biotechnology, where development times are accepted as being long in duration. It is likely that the current study will see a mixture of public and private funding for its USOs.

3.5.3 Uncertainty and information asymmetry

Two important concepts within the study of the attraction of external investment by start-up companies, including USOs, are uncertainty and information asymmetry (Manigart *et al.*, 2012; Meoli *et al*., 2012; Shane, 2004). Uncertainty for potential funders of USOs arises due to fundamental uncertainty over whether the relevant technology can be commercialised, and whether any market for it indeed exists. Information asymmetry arises due to the fact that the management team of the USO have more knowledge of their potential product or service than an external party, a situation exacerbated where the technology is complex or novel in nature (Munari and Toschi, 2010). It is therefore likely that a number of externally-financed USOs in the current work will fail, or fail to make a successful IPO/exit, as a result of these two important

factors. Under both signalling and agency theory frameworks, both factors will serve to hinder decision-making by potential investors, so where a USO's technology is particularly complex, on first principles the company may obtain lower amounts of funding.

3.5.4 Sources of capital

USOs raise capital from different sources depending on the company, with differences observed between USOs requiring minimal investment such as some software companies, and others requiring significant funding such as biotechnology companies. Shane and Stuart (2002) found that USOs from MIT with greater sales required less external financing than those with fewer sales, with a diverse range of funding sources which reflected the range of funding needs and the presence of uncertainty and information asymmetry in the funding process. Angel financing alongside venture capital funding, or by itself, was also common, reflecting its popularity with USOs given the longer timescales for returns, allowing more time for technology development for the USO, the tendency to invest earlier in the life cycle of the USO and the need for a lower rate of return. The current study is likely to reflect this range of sources of finance.

3.6 USO funding and performance

The effect of finance (particularly venture capital) upon financial performance, including the metrics of this study (survival and IPO/exit), has been considered in some studies both in USOs and wider start-up companies.

Shane (2004) states that the obtaining of adequate financial capital is associated with success of USOs, perhaps most critically in that it allows technological development to be undertaken via the hiring of personnel and purchasing equipment. In addition, given the generic uncertainty associated with USOs, financial resources give flexibility to change company strategy where new facts about the technology or market are uncovered. The process of raising financial capital is time consuming, and the need to raise further rounds can adversely impact upon the founders' time to spend developing their technology. Finally, financial resources imply quality and legitimacy making the USO more attractive to potential investors and leading to a virtuous circle. Prior research backs up these propositions: Shane and Stuart (2002) found for 134 MIT USOs founded between 1980 and 1996 that the cumulative amount of venture capital raised increased the probability of IPO and lowered the probability of company failure, with each $2m of venture capital raised doubling the probability of IPO. They used a database of MIT USOs that included all companies, freeing the sample from survivor bias, and noted that the majority of failures occur through lack of funding, demonstrating limitations of explaining how initial endowments affect USO performance in samples excluding early failures, a problem they consider to be rampant in research on new ventures. In addition, in the study there are no left censored company histories i.e. all USOs are observed from incorporation until a performance outcome is recorded or the observation is right censored by the end of the work. These are critical methodological issues that will be addressed in the current study. In a similar study, Lockett and Wright (2003) found that USOs with VC funding are ten times more likely to proceed to an IPO than other start-up companies. Nerkar and Shane (2003) similarly found that the more venture capital obtained by a USO, the more likely it was to survive.

Outside of the specific cases of USOs, the wider VC literature contains some examples of the effect that VC finance has upon company performance metrics similar to those already discussed. Hellman and Puri (2002) found that VC-backed firms show superior business performance that they attributed to the finance and business expertise provided by the VC. Other studies have shown that surviving VC-backed companies have higher growth rates in terms of assets, sales and number of employees (Al-Suwailem, 1995), and that VC-backed IPOs are on average larger than non VC-backed and experience less underpricing (Lin and Smith, 1998). Oskarsson and Schläpfer (2008) note that data about the financial performance of VC-backed companies in terms of survival and IPO is limited, but Metrick (2007) found that five years after incorporation, 6% of companies had failed, 33% had experienced an IPO or sale and 61% were still in the venture capitalists' portfolios. After ten years, 14% had failed, 61% had exited and 25% were still in portfolio, although it was suggested that many of the final category may in fact have failed and that the ten year timed failure rate was in the region of 30-40%. Nadeau (2011) noted that other studies show similarly high IPO and sale rates although the ratio between the two varies significantly between countries. Giot and Schwienbacher (2007) investigated VC exits by studying the time to IPO, trade sale or liquidation for 6,000 VC-backed companies. There was initially an increased likelihood of IPO rising to a plateau before decreasing over time. Trade sales were found to be less time-varying, with large variations across sectors.

Manigart *et al.* (2002) note that studies of VC impact on companies' financial performance often have a major flaw of survival bias where companies fail and disappear from studies, and which therefore only include survivors. An example of this is in studies of companies that succeed in an IPO, which is already a select group, and they note that apart from anecdotal evidence, little is known of the impact of VC on company survival, even though it is assumed to have a positive influence, and is demonstrated to some extent in some studies e.g. Calvo *et al*. (2012). However, Manigart *et al.* (2002) note that the relationship is unlikely to be straightforward, as VC investors seek to maximise their financial returns from their portfolio rather than ensure the survival of a single company, and note four reasons why VC-backed companies may survive longer than non VC-backed. Firstly, VC companies undertake stringent due diligence to pick the best investments. Secondly, Diamond's (1991) reputation-based theory suggests that investors such as VCs transmit positive signals to other potential investors and help to attract other resources. Thirdly, VC managers undertake monitoring after investment (Lerner, 1995), and finally provide valuable services to their portfolio companies such as access to networks and business knowledge (Fried and Hisrich, 1995).

However, there are also arguments against VC having a positive influence on survival. Amit *et al.* (1990) argue that VC is a costly form of finance and the most promising projects may be able to acquire cheaper finance from other sources. VC investors also aim for maximum financial return so may seek out more risky companies than non VC-backed ones as part of a large portfolio of investments (Manigart and Sapienza, 1999). Finally, VC managers may act to liquidate 'living dead' companies that are surviving but not producing an adequate financial return (Ruhnka *et al.*, 1992) to allocate their time more efficiently to their better-performing investments. Ruhnka *et al.* (1992) found that VCs could turn around 56% of their living dead investments by devoting more time to them, although Sapienza (1992) found a strong positive correlation between VCs' time invested and the performance of the company, suggesting the latter strategy may lead to lower chances of survival. In one study focussing on the performance metric of survival,

Manigart *et al.* (2002) considered the survival of VC-backed Belgian companies compared to those without VC and found that, in opposition to previous views (e.g. Shane and Stuart, 2002; Timmons and Spinelli, 2002), VC-backed companies did not show higher rates of survival.

Manigart *et al.* (2002) also propose that the type of VC obtained is likely to influence the survival of an investee company, distinguishing between private VC and government VC. Governments have often used VC to exploit public benefits and diminish perceived equity gaps, so government VC companies may look to social returns such as job creation rather than solely focussing on financial performance, which may lead to lower survival rates than private VC. In addition, government VC is managed by civil servants who may not be the best qualified to identify good investments and the lower salaries offered than private sector VC may again serve to diminish their effectiveness. However, government VC may actually be able to finance the best projects due to their ability to offer cheaper finance than private VC, and having societal goals may make it more likely that government VC managers will seek to turn around living dead companies rather than liquidate them, which could lead to greater survival rates than for companies funded by private VC.

In conclusion, the relationship between finance and survival/IPO is not straightforward, as seen in the above studies. Although focussing mainly on VC funding, these conclusions are likely to apply to other sources of funding. The current study will therefore add important data to the discussion.

3.7 Theoretical frameworks

The collection of financial performance data in this work needs to be grounded within a suitable theoretical framework to provide structure to subsequent analysis. Selecting a framework is not always straightforward, and is unlikely to leave no unresolved queries or issues when attempting to explain observations and results. However, the existing literature can provide some guidance to enable a suitable framework to be identified and allow a more effective and challenging set of questions to be raised and conclusions to be reached.

The overall aim of this work is to assess the effectiveness of the recent USO creation phenomenon in the UK by focussing on financial performance of USOs at a company level within the context of its parent university. Such performance data serves to demonstrate the underlying strength of the USO in terms of the resources it owns and the effectiveness of their use to external third parties. It also allows conclusions to be drawn upon the intrinsic commercial value of the underlying technology being developed and the ability of the university, via its technology commercialisation operations, to effectively identify technology, commercialise it and create financial value for the university. The overall research question is a broad, policy-focussed one and the aim of this work is to provide evidence to policy-makers through a detailed longitudinal study of a region rather than to examine relationships between financial variables and other data. This is likely to make the selection of a framework challenging and it may be that elements need to be borrowed from a number of frameworks. In addition, the data collected may only be sufficient to be acknowledged as in line with what a framework might predict.

As illustrated in Section 3.4 above, the majority of studies previously undertaken in the literature that provide comparable data to this work have been atheoretical in nature. Where a theoretical model has been used, the RBV (Resource-Based View) is the most common e.g. Mueller (2010). This framework is examined in more detail below.

As can be seen from the broad nature of the overarching research question in Chapter 1, the key purpose of this work is to investigate absolute financial performance measures of USOs to address a broad policy question of whether such companies have been successful in a UK region from a financial perspective. This is to be achieved by collection of an extremely accurate and precise population to allow analysis to be made at an individual company level. A tight definition of a USO will be made for these purposes and data collected from a range of historic accounting records to allow comparison with other works. This is in contrast to the approach of previous studies.

As a result of the methodological differences between this work and comparable studies, and the policy-focussed nature of the overarching research question, the RBV framework previously used in the literature may not provide a comprehensive overview for the requirements of this study.

The RBV provides a theoretical viewpoint which focusses on the resources of a firm as a differentiator and predictor of competitive advantage, and gives rise to resource-based theory. It considers the starting resource configuration of a company and links superior performance to organisational resources and capabilities (Mustar *et al.*, 2006), which the company may have when it is founded, or which it is able to acquire or develop over time. Barney (1991) developed a popular model which attempts to classify the complete set of resource characteristics needed to obtain sustainable competitive advantage, which is often known as the 'VRIN' model where resources must have the following properties:

- valuable,
- rare,
- inimitable, and,
- non-substitutable.

Landry *et al.* (2007) have produced the following diagram focussing specifically upon the resources required in a successful process of USO formation and development. As can be seen, the quality of the underlying commercialisable technology and its protection is of paramount importance. Other mainstream resources such as finance and the personal and network resources of the founders are also listed. The institutional context is also represented with resources relating to the parent university included in the diagram; USOs have historically primarily been generated from science and technology departments at universities, so universities with significant research strengths in this field may lead to the formation of more USOs than those universities which do not.

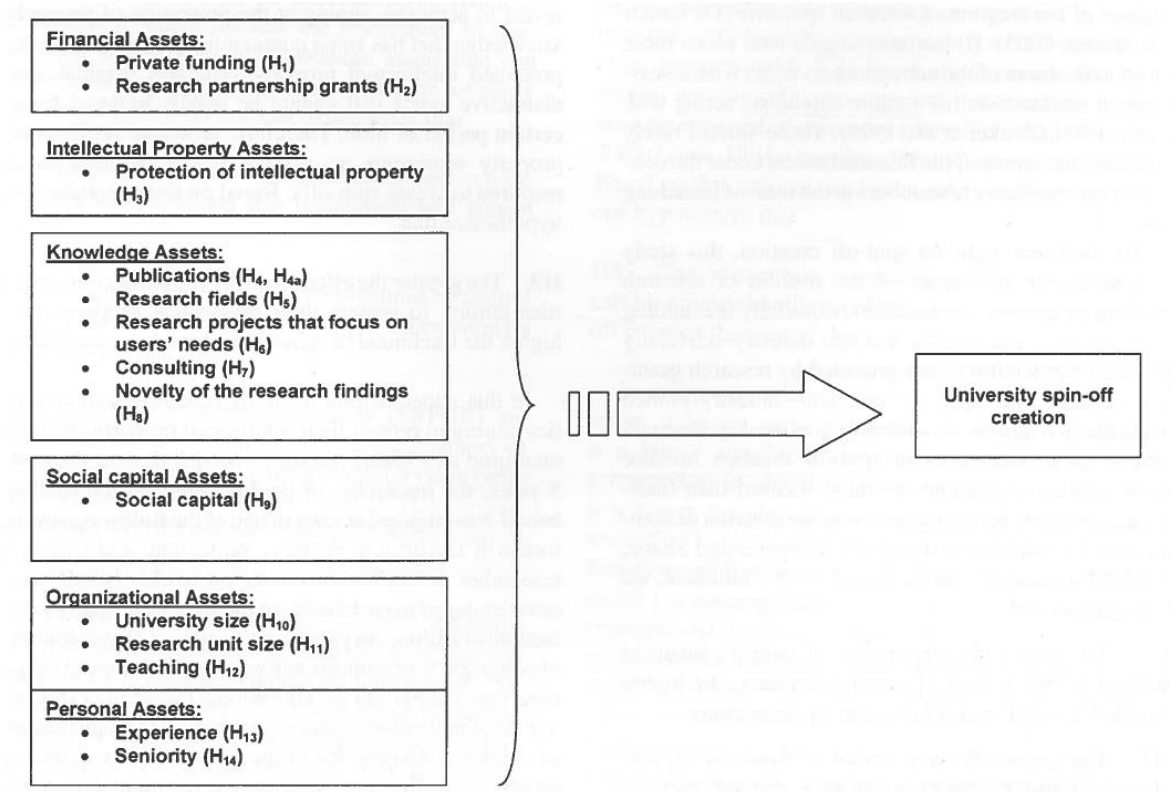


Figure 3.2 Resources required for USO formation and development (Landry *et al.*, 2006)

As already noted, the RBV has already been used extensively in the academic study of USOs, including some financial performance studies at a company level, where the performance of USOs is linked to the resources that they hold e.g. Munari and Toschi (2010). In other studies, Arthurs and Busenitz (2006) built upon the RBV to explain how venture capitalists (VCs) endow new ventures with greater product dynamic capability resulting in significantly higher IPO and post-IPO performance, while Thornhill and Amit (2003) undertook an RBV analysis of company failures finding inability to adapt to environment change to be a key cause. It will therefore have some relevance in the current work as the possession of resources would be predicted to lead to outperformance under the RBV, implying that USOs with more effective resources will be more likely to attract external financial resources, survive or reach a successful exit. In particular, the attraction of finance, which is both a performance metric and a resource under the RBV, may lead to superior financial performance under the other two metrics.

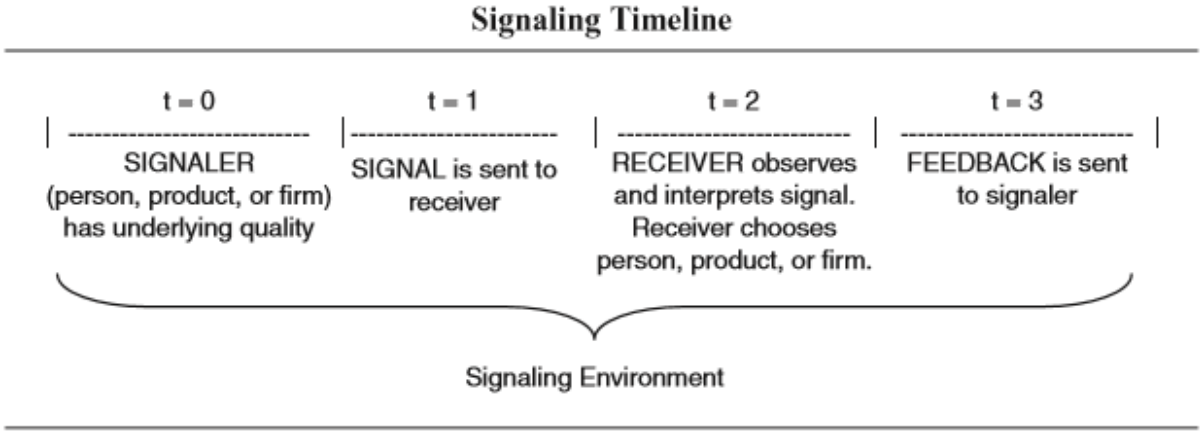
However, the RBV will not be used as the main theoretical framework for the current work which focusses on financial performance. While financial resources are a key resource within the RBV, the overall framework requires consideration many other categories of resource as illustrated in Figure 3.3, rather than simply the narrow consideration of the financial resources of the USO to allow effective analysis to take place. Within the confines of the methodological approach of the current study in focussing on collecting accurate financial data, it will not be possible, for example, to assess the strength of a USO's technology, or its human and social capital which may serve to attract external investment.

It is therefore necessary to consider additional theoretical models. On this basis, two theoretical models popular in the literature that may be of some value are signalling theory and agency theory, which will be outlined briefly below. Signalling theory, which has been used in previous performance studies e.g. Mueller (2010) is concerned with signals given by entities to external third parties which may affect the relationship between the two parties going forward. Such signals will include financial performance data for USOs which will be the focus of this work. In addition, agency theory can potentially provide some insight into the relationship between two key parties in this work i.e. the principal (an interested external party) and agent (the university via its TTO).

3.8 Signalling theory

Signalling theory is a popular theoretical framework used in a variety of strands of academic literature, including that of entrepreneurship (Ahlers *et al*., 2015), and at its core is concerned with the reduction in information asymmetry between two parties (Spence, 2002). Information asymmetry has been described as occurring when 'different people know different things' (Stiglitz, 2002), and arises where imperfect information exists. Stiglitz (2002) identifies two broad categories of information where asymmetry is important: information about quality, which is important where one party is not fully aware of the characteristics of the other, and information about intent, which is important where one party is concerned about the other's behaviour (Connelly *et al*., 2011). This second category is closely linked with agency theory, which is described in greater detail below. Connelly *et al*. (2011) define quality as 'the underlying, unobservable ability of the signaller to fulfil the needs or demands of an outsider observing the signal', although other interpretations exist in the literature.

Connelly *et al*. (2011) prepared the following timeline to review the key elements of signalling theory, which includes the two key actors, namely the signaller and receiver, as well as the signal, and these concepts are discussed below.



Note: t = time.

Figure 3.3 Signalling timeline (Connelly *et al*., 2011)

3.8.1 Signaller

Signalling theory identifies the signaller as an insider e.g. Spence (1973), who has information that is not available to outsiders. This may include positive or negative information, which in the context of a USO could include details of the company's underlying technology. Entrepreneurship studies usually focus on signallers as leaders of start-up or IPO (Initial Public Offering) firms e.g. Zimmerman (2008).

3.8.2 Signal

Spence (1974) describes signals as 'those activities or attributes of individuals in a market which by design or accident, alter the beliefs of, or convey information to, other individuals in the market'.

Signalling theory studies generally focus on the deliberate communication of positive information by signallers to convey positive attributes about an organisation (Connelly *et al*., 2011). To be an effective signal, it must be observable, so outsiders can notice it, and costly to produce (Bird and Smith, 2005), so signallers can be seen as well placed and able to absorb the cost. Ndofor *et al*. (2004) define effective signals as those that create a 'separating equilibrium', which is one where an uninformed agent is able to distinguish between superior and inferior endowed firms (Kreps and Wilson, 1982).

A wide range of signals of quality have been considered in the literature. One important approach considers signalling theory alongside institutional theory where firms strive for legitimacy to survive, with typical signals being the quality of their directors or management, or of their shareholders. For start-up companies, founder share ownership can be a costly signal of quality given the need for them to invest their own resources. Arthurs *et al.* (2009) note, in the context of an IPO, that signals of quality include scientific capabilities (Deeds *et al*., 1997), venture capital backing (Megginson and Weiss, 1991), prestigious underwriting (Carter and Manaster, 1990) and length of lockup agreement, to reduce current and potential investors' doubts of a company going through an IPO.

3.8.3 Receiver

Receivers are outsiders who lack but desire information about an organisation. Connelly *et al*. (2011) note that for signalling to occur, the signaller should benefit by some action from the receiver that the receiver would not otherwise have done, and often involves selection of the signaller from other alternatives. In entrepreneurship literature, this often includes a decision by the receiver over whether to invest as an existing or potential investor (Busenitz *et al*., 2005), including at IPO stage (Arthurs *et al*., 2009), and this will be applicable to USOs also.

3.8.4 Relevance of signalling theory for USOs

Signalling theory is likely to be of relevance in the study of USOs in the current work. USOs, as signallers, along with other start-up companies created to exploit new technology, are obvious cases where potential investors lack information (Gompers and Lerner, 1999), with limited

operating history available to allow external parties to make good investment decisions. Audretsch *et al*. (2012) note that new ventures are particularly prone to financial constraints and that innovative new ventures usually rely on external finance, although information asymmetry is a particular problem given the lack of any track record for the company, and uncertainty about the value of the technologies, particularly at an early stage of existence. In a similar vein, Cao and Hsu (2010) note that start-up firms are characterised by large intangible assets, negative cash flow, great technological uncertainty and low liquidation value, and hence must rely on venture capital for finance, with the existing literature showing a focus on how VCs mitigate information asymmetry through financing strategies. It is likely that the attraction of external investment will be a relevant performance metric for USOs in the current study, and data should be able to be evaluated for consistency with the signalling theory framework.

Signalling theory may also be of value when considering financial performance data from USOs generated from a specific university and its TTO. Williamson (1996) identifies three mechanisms reducing uncertainty surrounding any transaction, namely trust built up through multiple transactions, greater information disclosure and bonding. There may therefore be a link between the number of USOs formed by a TTO and the level of external funding obtained, both of which may be performance metrics of relevance. The third element of bonding may include, among many factors, reputational capital of the TTO which would only seek to commercialise high quality technologies, or the ownership of an equity stake in the USO. Arthurs *et al*. (2009) consider such a bond as a stronger form of signal than those elements mentioned above, since if the information provided is incorrect the TTO itself will suffer financial or reputational loss.

Finally, signalling theory may be able to provide a framework against which to gauge consistency when considering the survival of USOs, another performance metric likely to be of interest. Hsu and Ziedonis (2008) note that prior studies identify two mechanisms where quality is signalled, namely entrepreneurial experience of management teams and knowledge and capability transfer from a parent (Agarwal et al., 2004) which affects new ventures' probability of survival. Linkages between the research strength of the parent university and the survival and performance of its USOs may therefore be possible to explore.

3.9 Agency theory – introduction

Eisenhardt (1989) states that the historical background behind the development of agency theory arose from work performed by economists in the 1960s and early 1970s on risk-sharing problems where co-operating parties have different attitudes to risk. Agency theory broadened this work to include the agency problem occurring where the parties have different goals and division of labour (Jensen and Meckling, 1976). Agency theory is directed at the agency relationship where one party (the principal) delegates work to another (the agent), and describes the relationship using a metaphor of a contract.

Agency theory primarily considers two problems that can occur in agency relationships (Eisenhardt, 1989). The first is the agency problem arising when a) the desires or goals of the principal and agent conflict, and b) it is difficult or expensive for the principal to verify what the agent is doing and whether they are behaving appropriately. The second problem is that of risk sharing where principal and agent have different attitudes towards risk, and hence may prefer different activities to be undertaken.

Table 3.10 below gives an overview of the key tenets of agency theory which are discussed further below.

Key idea	Principal-agent relationships should reflect efficient organisation of information and risk-bearing costs
Unit of analysis	Contract between principal and agent
Human assumptions	Self-interest Bounded rationality Risk aversion
Organisational assumptions	Partial goal conflict among participants Efficiency as the effectiveness criterion Information asymmetry between principal and agent
Information assumption	Information as a purchasable commodity
Contracting problems	Agency (moral hazard and adverse selection) Risk sharing
Problem domain	Relationships in which the principal and agent have partly differing goals and risk preferences e.g. compensation, regulation, leadership, impression management, whistle-blowing, vertical integration, transfer pricing

Table 3.10 Agency theory overview (Eisenhardt, 1989)

3.9.1 Agency theory in VC literature

Agency theory has proved a popular theoretical framework in which to explore the relationship between a venture capitalist and entrepreneur (Arthurs and Busenitz, 2003), where the VC is considering providing finance to a new company set up by the entrepreneur. Under agency theory, an agency problem can arise between the entrepreneur (agent) and VC (principal) as a result of different risk preferences and goals (Eisenhardt, 1989). As noted above, the theory assumes both parties are self-interested and boundedly rational, with individual utility-maximising behaviour likely to occur if incentives and controls to align the goals of the entrepreneur with the VC are not put in place.

While the current work focusses on the university TTO rather than the academic entrepreneur behind the USO, similar issues are likely to be at stake since the TTO, a quasi-commercial operation within an academic environment, may have quite different goals and risk appetite from those of an external financier (Vohora *et al*., 2008) who is likely to be focussed primarily on financial returns. It would seem therefore that agency theory may have some utility and relevance for the current work, given that attraction of external investment is likely to be an important performance metric.

Arthurs and Busenitz (2003) note that bounded rationality of the two parties (principal and agent) may give rise to information asymmetry leading to adverse selection or moral hazard on behalf of the agent (Amit *et al*., 1998). Adverse selection is the misrepresentation of ability by the agent e.g. in the current study the TTO 'overselling' the quality of the USO's underlying technology to the potential financier, while moral hazard relates to negative behaviour such as lack of effort by the agent e.g. the TTO might not perform proper internal due diligence on the quality of the technology or management team of the USO.

3.9.2 Boundaries of agency theory

Within the context of a VC/entrepreneur relationship, Arthurs and Busenitz (2003) consider that agency theory is able to function as a theoretical framework better at certain points in the investee company's lifecycle than at others. They note that a normative prescription of agency theory is that the principal should try to avoid or mitigate any agency problem, but that the problem will vary throughout the lifecycle of a company, hence agency theory is also likely to vary in its usefulness as a framework within which to explain observed results. In the current work, agency theory may be most efficient as a framework prior to financial investment when the TTO may have greater input into the management of the USO, when any agency problem may decrease as the TTO and financier's goals become aligned.

Figure 3.3 below is derived from Arthurs and Busenitz (2003) and identifies the nature of the agency problem depending on the goals of the TTO and financier; the outcomes are discussed in more detail below, with specific reference to the TTO and financier of this work.

	Perceived goals between financier and TTO		
Actual goals between financier and TTO		Same	Different
	Same	No agency problem	Perceived agency problem
	Different	Hidden agency problem	Visible agency problem

Figure 3.4 Goal congruence between financier and TTO (derived from Arthurs and Busenitz, 2003)

Where the goals of the financier and TTO are aligned, as in the upper left quadrant, there is no agency problem (Eisenhardt, 1989) e.g. both parties wish to maximise the value of their equity stake in the USO. Arthurs and Busenitz (2003) note that agency theory prescribes actions for the financier to move into this quadrant such as monitoring and evaluating the value of the USO's underlying technology; however, agency theory has less value in describing behaviour once this situation of goal congruence has been reached and any agency problem mitigated or overcome. Such monitoring might include the financier appointing a representative director to the USO's board or evaluating the USO's financial performance by reviewing regular management accounts.

In the upper right quadrant, the actual goals of the financier and TTO are the same but the financier perceives them to be different. Arthurs and Busenitz (2003) identify that a blind spot for agency theory develops in this scenario, as it mistakenly assumes goal misalignment as causing an agency problem. As a result, the financier may undertake excessive monitoring to overcome this perceived problem, with an example of this situation in the current work being where the financier feels that the TTO is focussing on other goals for the USO other than financial success, such as letting a failing company survive to protect its own reputation. Where research focusses only on either the principal or agent, agency theory will produce significant or

insignificant results respectively, leading to potential errors in the findings. The current work will therefore consider both TTO and financier perceptions to overcome this potential issue.

Where goals of principal and agent are different, a potential agency problem exists and agency theory's assumptions are valid for the bottom two quadrants. Agency theory advises that the principal should offer incentives to, or monitor the agent to move from the bottom left to bottom right quadrant, and thence to the top left, where goals are aligned.

Arthurs and Busenitz (2003) state that actual and perceived goal alignment help to explain why agency theory may be more applicable as a theoretical framework before an investment decision is made than after it. Before investment, the financier is likely to focus on conducting a thorough due diligence of the USO to avoid a bad investment decision. The financier does not know the motivation of the TTO, and must assume the worst and protect his investment. The TTO's primary goal is likely to be USO success, so actual goals of principal and agent are different, giving potential agency problems. However, after investment, the goals of the financier and TTO are likely to become USO success and are hence aligned, although the financier will undertake actions to safeguard its investment and avoid potential hidden agency problems.

The due diligence process conducted by the financier occurs at the time when its uncertainty over the USO and TTO is likely to be highest, reducing adverse selection or moral hazard fears. Arthurs and Busenitz (2003) identify four other mechanisms that reduce potential for agency problems: TTO bonding (Jensen and Meckling, 1976) where the TTO (or university) has a significant equity stake in the USO, contractual obligations of the TTO specified in the financing agreement, incentives provided by the financier and ongoing monitoring of the USO by the financier.

Following investment, the relationship between TTO and financier may develop to include working together on other projects as trust develops between principal and agent. In the current work, this may be observable if the same external financier returns on multiple occasions to provide finance to new USOs from the same TTO. The likelihood of an agency problem is therefore likely to decrease over time, although certain situations could reverse this e.g. the financier realises that a USO is not likely to be successful.

In the current work, it may be that the TTO has a wider range of goals than that of the financial success of the USO, which as already noted is likely to be the key focus of the financier. For example, the TTO may have a reputational goal in that USOs that do not survive for many years may have a perceived negative impact on the TTO's reputation for commercialising technology. As such, the TTO may prefer to keep USOs alive as 'living dead companies' e.g. Ruhnka *et al*. (1992) rather than take the pragmatic commercial decision of a financier to close and liquidate the USO to avoid further losses. The TTO may also have regard to the positive impact of a USO on the local economy to satisfy local government stakeholders, which could manifest itself in a TTO creating large numbers of USOs with a consultancy slant to their activities, but which would not grow rapidly e.g. the 'lifestyle' companies (Wright *et al*., 2006) seen in Chapter 2. These aspects will need to be considered carefully in analysing the financial results of this work.

3.9.3 Potential limitations of agency theory

While agency theory can be helpful to describe observations in a financier/entrepreneur situation, there are certain limitations to its powers. Arthurs and Busenitz (2003) note that there is in fact a general lack of empirical support in the literature for an agency relationship between VCs and entrepreneurs (Busenitz *et al*., 2001). This may be due to previous studies focussing on inappropriate agency variables, or limitations in agency theory's explicative ability. As already noted, they consider agency theory is more limited in its use after external investment than before, for three main reasons, as adapted for the current work:

- The goals of financier and TTO become aligned, mitigating potential agency problems
- After investing, the financier changes from wary investor to willing collaborator
- The TTO retains a significant stake in the USO, either equity or a more intangible attachment

However, in a more fundamental challenge to the usefulness of agency theory in a financier/entrepreneur relationship, Arthurs and Busenitz (2003) argue that an entrepreneur in fact rarely acts like an agent under agency theory. The entrepreneur is, in reality, unlikely to pursue short-term gain at the expense of success given the fundamental uncertainty over the USO's future, so is unlikely to undertake any activity to jeopardise its survival. This may again serve to limit the theory's ability to explain results from a study. Further, agency theory focusses primarily on protection of a financier against downside, whereas the field of entrepreneurship is usually about stakeholders pursuing upside potential and less about downside protection. Upside potential under agency theory is limited because the entrepreneur is supposed to have little concern for long-term success, but this is unlikely to be true in the current study as the TTO is likely to be concerned over the success of the USO, as observed in the simple fact that it engages the financier for funding to maximise long-term success.

3.9.4 Agency theory – relevance to USOs

As with signalling theory, at this stage it is possible that agency theory will be of some value as a theoretical framework for the current work, given its use in the more generic situation of a relationship between a VC and entrepreneur, in particular to explore the financial performance of USOs within the context of the relationship between the TTO and external financier. Not all USOs will attract external finance (Lambert, 2003), but those that do should yield results of interest. Agency theory has been used in some recent studies of USOs e.g. Prencipe (2016) However, results must be treated with care for a number of reasons due to limitations in the theory itself.

Agency theory traditionally has a focus on the preservation of wealth of investors, which may provide an incomplete picture of the TTO, and to a lesser extent the financier, turning the focus from the TTO to the financier counter to entrepreneurship research (Arthurs and Busenitz, 2003). The basic agency theory model may need to be adapted for issues such as accounting for trust in a relationship and view financier involvement as a form of collaboration to grow the USO, rather than simply a financial contribution.

In general, agency theory has been considered to have varying degrees of utility depending on the stage in the lifecycle of a company. Previous work has considered it to have greater

explanatory value in the initial stages of a company to explain implications of separation of management and control, but a critical issue that limits agency theory relevance after investment is the assumption that VC and entrepreneur goals are divergent, which may not be the case in this work for the TTO and financier.

3.10 Conclusions

This chapter has identified two theoretical frameworks, namely signalling theory and agency theory, which may be of benefit for the current work within which financial performance data from USOs may be assessed. Both frameworks will offer some insight into the key performance metrics identified, in particular the attraction of external finance by the USOs, although this can be extrapolated to the successful exit metric which represents a special case of fundraising, and also to survival which will be impacted by the fundraising. However, given the restricted range of financial data to be collected, it is likely that reference can only be made to these frameworks to the extent that findings are consistent with their expected results. The overall emphasis of this work remains the detailed financial data obtained from a longitudinal study which seeks to inform policy-makers of the overall success or otherwise of USOs, rather than focussing on relationships between certain financial metrics.

The RBV, while popular in similar studies to date, will not be used to any significant degree in this work as financial resources of a USO, which is one of the performance metrics in the chosen model, would be the only resource under consideration. The overarching research question of this work is broad and policy-based, and the focus will be on accurate analysis of secondary quantitative data rather than undertaking an econometric study using a framework which requires qualitative data.

This chapter has also covered in some detail potential financial performance metrics to be used in the current work in order to answer the overarching research question, by analysing the wider literature to date and assessing the effectiveness of metrics already used. The three metrics chosen, designated the ‘triumvirate’, are attraction by a USO of external investment, survival and successful exit. A literature review was undertaken of all studies to date where these three metrics have been used to analyse the financial performance of USOs, and the results collated in tabular form for future comparison against the results of this study. A brief analysis of the methodology used by each of these studies was made to inform the proposed methodology of the current study, and the need to focus on obtaining an accurate dataset of USOs.

Finally, a brief review of the existing literature, both for USOs and start-up technology companies in general, was performed into the effect of obtaining external investment on the performance metrics of survival and IPO/exit. A wide range of results observed leads to the conclusion that any relationship will not be straightforward, and means that any contribution from the current study will be valuable for the literature. The obtaining of external finance is the key metric in the ‘triumvirate’ of performance measures of this study, being both a metric itself and potentially influencing the other two.

Chapter 4: Research Paradigm, Methodology and Design

4.1 Introduction

This chapter discusses briefly the subject of research paradigms and identifies the most relevant paradigm in which this particular piece of work falls, as well as the generic research methodology which will be used to investigate the overarching research question of Chapter 1. It then undertakes a review of the methodologies used by key comparable studies in the literature and comments on their effectiveness. A detailed research design for the work is then laid out including identifying the external sources from which a database of USOs will be constructed, as well as the nature of the survival, exit and external investment data collected, following the identification of these key performance metrics in Chapter 3. The context of the region under analysis is considered and the need for a case study to verify the approach taken, using the University of Birmingham, is discussed. Finally, it considers the nature of the analysis to be performed upon the data collected, and the extent to which any trends observed are consistent with the theoretical frameworks of signalling and agency theories, also identified in Chapter 3 as of potential value in this work.

4.2 Research Paradigms and Methodology

This thesis seeks to investigate the financial performance of USOs at a company level, a topic that, in common with all areas of research, falls within a 'research paradigm'. This may be thought of as a 'world view', or 'position on the best ways to think about and study the social world' (Thomas, 2009). The choice of a research paradigm influences the research subsequently undertaken in a number of ways (Murphy, 2013):

- What is considered problematic i.e. what warrants research
- The types of questions that follow from this
- What kind of data, and therefore what kind of methods are chosen
- Within those methods, how the concepts/constructs to be explored are operationalised and analysed

Murphy (2013) notes that a research paradigm is by nature broad-based, and different research positions can be taken within a paradigm, even though researchers are agreed about the way particular problems exist and the ways they can be investigated. Within research paradigms, researchers have identified two important concepts:

- Epistemology – theories about what we know about the world and how we know it
- Ontology – theories about existence or being and how we understand the social world

The research methodologies used in a piece of work, or 'specifying how research questions should be asked and answered' (Teddlie and Tashakkori, 2009) are determined by the above concepts as to how the research problems and questions are addressed, as well as practical operational matters such as the availability and completeness of data.

There are a number of possible research paradigms which have been identified, but two of the most significant are positivism and interpretivism. Positivism is often associated with research in the field of natural sciences, focussing on a refusal to speculate beyond what can be supported

by the obtaining of empirical evidence, especially evidence derived by observing phenomena. Researchers within this paradigm often have a tendency to act in the following ways (Murphy, 2013):

- Use the experimental method and/or the forms of statistical analysis modelled on it, to engage in the careful measurement of phenomena
- Rely on quantitative data
- Seek causal or statistical relationships among variables

Positivists also believe in an external, objective reality and that research should be able to be replicated by different researchers given that the research methods utilised are both transparent and objective. Samples of sufficient size and representativeness are required to ensure objectiveness (Mueller, 2010). Within social science research, positivism may sometimes be considered simplistic given the complexity of social entities.

The second main research paradigm, which is often considered to be in contrast with that of positivism, is that of interpretivism. This paradigm considers phenomena investigated in research areas such as social sciences to be very different from those in natural sciences. A key tenet of interpretivism is that people interpret their environment and themselves in ways shaped by the culture in which they live (Murphy, 2013), which has the following implications for research:

- Interpretivism has encouraged a shift towards qualitative research methods
- The researcher should adopt an exploratory orientation
- Data should be structured as little as possible by the researcher's own prior assumptions

Interpretivism thus usually relies on qualitative data and constructs theory on an inductive basis. In line with positivism, its strengths are that it can deal with complex scenarios, but may be difficult to relicate given the significant role of the individual researcher.

4.3 Research Paradigm and Methodology for the Current Work

The research undertaken in this thesis appears to fall clearly within the positivist paradigm as it focusses on obtaining empirical evidence in the form of financial performance data for USOs at a company level i.e. the USO is the unit of analysis, across a number of different universities using data collection and analysis methods that can readily be replicated. This is critical as the study seeks to compare the West Midlands region with other regions, and replicability is vital to make this work of value. On a more abstract level, the financial data is in numerical format and forms an external, objective reality.

Expanding upon Murphy's (2013) observations above, experimental methods in the form of the research methodology are used and financial performance data phenomena collected and measured carefully. Data is exclusively in quantitative format and relationships between universities and the financial performance of their USOs sought. Given that human beings and their interpretations do not form part of the data collected, the interpretivist paradigm is not of primary significance in this particular work. However, informal discussions were held with USO management and university staff to supplement the numerical data and provide some insight

into the trends revealed by the data collected. As a result, the positivist paradigm is the model of choice for this work.

4.4 Methodology Review of Comparable Studies

The table below shows, for the key comparable studies of USO financial performance in the literature, the theoretical models used, the main data source and the performance metrics investigated (those which correspond to those chosen in this work).

Author	Theoretical model used	Main data source	Performance metrics investigated
Shane (2004)	Range of models used	Commercial US database and other studies	Survival
Clayman and Holbrook (2006)	Atheoretical	Canadian university-industry liaison offices	Survival
Leung and Mathews (2011)	Atheoretical	Hong Kong university TTOs	Survival
Wennberg *et al*. (2011)	Atheoretical	Publicly-available government database and Statistics Sweden LISA database	Survival
Zhang (2009)	Atheoretical	Commercial database (VentureOne)	Survival, external investment, IPO
Holi *et al.* (2007)	Atheoretical	Private database (Library House)	External investment
Mueller (2010)	RBV and signalling theory	Library House database and questionnaires	External investment
Munari and Toschi (2010)	Atheoretical	Trade body (MNT Network) and commercial database (Venture Expert)	External investment
Minshall and Wicksteed (2005)	Atheoretical	University TTOs	External investment

Table 4.1 Comparable study research methodologies

The above information assists in shaping the research methodology and design of the current work. As discussed in Chapter 3, the majority of the comparable studies to date are atheoretical in nature, so this work seeks to fill this gap in the literature. The sources of data are varied but questionnnaires and data supplied by TTOs have been frequently used, with the problems inherent in their accuracy as previously discussed. As a result, this work seeks to add to the literature by considering a range of sources to obtain an accurate dataset. Finally, the established nature of the three performance metrics chosen in Chapter 3 gives confidence that those are relevant to this field and are worth investigating.

4.5 Research Design of the Current Study

While the financial performance of USOs at a company level is the subject of an increasing number of academic papers, there are still methodological difficulties in conducting such

studies, as discussed above in Chapters 2 and 3, and as a result there remain significant gaps in the literature. As noted above, the key difficulties in conducting studies on USO financial performance include the lack of publicly available data from sources independent of the company itself or university (Lawton Smith and Ho, 2006), the lack of clarity over the definition of a USO (Zahra *et al*., 2007) and the difficulty in obtaining a complete population of USOs over a long period of time to avoid survivor bias (Shane and Stuart, 2002). The current study seeks to address all three of these concerns.

The purpose of this work is to analyse the financial performance of USOs originating from universities in the West Midlands region. However, this will be done with a different focus to previous studies. This work relies upon analysing a number of independent objective sources in line with the overall positivist paradigm to create a very accurate data set of USOs formed over a long period of time. It then examines the published accounts of the USOs in great detail by extracting a range of accounting information, building up a narrative of the history of the company over a significant period of time, many of which are no longer in existence. Previous studies in this area, as noted in Chapter 3, have focussed more on the econometric analysis of data, which is often likely to be incomplete or be unable to make any allowance for the very different forms of USO that a single university will generate.

Once an accurate data set of USOs has been created from this time-intensive process, it is much simpler to make comparisons of performance between companies and universities, and to be confident that trends observed in one university can be compared and contrasted with those in others. While the unit of analysis of this work is the USO, as noted above the relevant university and region will be closely associated with the USO and comparisons between universities and regions, where undertaken with care, are an important part of this work. Such a methodology overcomes the difficulties in other studies observed by Shane and Stuart (2002), who noted that many studies suffer from significant survivor bias, in that USOs that fail are often left out of datasets due to lack of information and knowledge. In addition, this study avoids the problem of left-censored company histories as companies are traced from incorporation throughout their whole life cycle. This study will produce descriptive quantitative financial performance data of a high quality and accuracy, which can then be compared with previous studies, as well as between the universities within the region.

4.6 Further research questions

The study examines survival, the ability to attract external investment and the reaching of an IPO or other successful exit as the USO financial performance metrics, as they are considered to be the best metrics in line with the analysis above in Chapter 3 (Rasmussen *et al*., 2012), with the unit of analysis being the USO. This selection fits well into the findings of the Library House (2008) report discussed earlier and form the 'triumvirate' model. As a result of this identification, the overarching research question from Chapter 1 is further expanded to incorporate the following three broad supplementary questions covering these chosen metrics:

a. How do USOs originating in the West Midlands perform in terms of survival?
b. How do USOs originating in the West Midlands perform in terms of attracting external third party investment?
c. How do USOs originating in the West Midlands perform in terms of reaching a financially successful IPO or exit for the university?

As identified earlier, these three performance measures are closely linked, with the attraction of external finance being seen in other areas of academic literature as potentially influencing the success of a company in respect of the two other metrics e.g. Shane and Stuart (2002), and the performance model chosen can be further explored by considering the relationships between the metrics in two additional research questions:

d. How does the attraction of external finance affect a USO's survival?
e. How does the attraction of external finance affect a company's ability to reach an IPO or successful exit?

Results from this section are compared with similar studies in the VC literature. The nature of these relationships will be descriptive in this work based on using the high quality data obtained, and this work will not attempt to examine the nature of the relationship using econometric analysis, but the findings will be compared with the results of existing studies. The attraction of finance is, of course, only one element in the subsequent performance of a company, and it should be noted that there is a danger of endogeneity in focussing only on a single factor. The RBV e.g. Landry *et al*. (2006), a theoretical model discussed briefly in Chapter 3 highlights the fact that a USO needs a range of resources other than finance to be formed and undertake activity.

The performance of the West Midlands USOs is compared against the results in the literature from other UK and foreign universities, again on a descriptive basis, to identify differences between regions, as well as potentially to evaluate differences arising from the research methodology of the current work, with the following question:

f. How does the West Midlands USOs' financial performance compare to USOs from other universities in the UK and abroad?

Finally, in line with previous studies in the USO literature, although outside that of USO company performance, to incorporate elements of the university/institution effect, two further questions are raised to allow comparison with previous studies:

g. Is the attraction of external financing by USOs influenced by the research strength of the parent university?
h. Is the number of USOs created influenced by the research strength of the parent university?

Given the wide range of universities and the support they provide to USOs, a wide range of results is expected. Background information on each university is provided alongside financial data and the range discussed in the analysis of subsequent chapters.

4.7 Data sources: USO identification

The data collected for this work is mainly secondary in nature i.e. obtained from existing data sources. This is a key component of the current research which aims to differentiate itself from the existing literature by producing a very accurate dataset of USOs from a number of objective sources independent of the USO or university technology transfer apparatus. The universities in the West Midlands geographical region were identified and an initial case study performed on the University of Birmingham to confirm that the proposed methodology and data sources were

viable, the results of which are discussed in Chapter 5. The case study was then reperformed for all other universities within the region. Data was collected between March 2014 and March 2015.

In addition, throughout the course of the financial data collection, informal conversations were held with TTO staff at Warwick and Birmingham universities, and a number of founders, directors and employees of USOs still trading across a range of the universities. These informal discussions served to inform subsequent analysis and provided potential justifications for trends in data observed, ensuring that such analysis was not solely the value judgements of the author.

USOs for each university were identified by combining data from four separate independent sources, which were identified from analysis of options on the market and chosen for the accessibility and quality of data:

4.7.1 The university's published accounts

Most of the UK's universities are constituted as charities, and as a result of their size are required by law to prepare and file detailed financial accounts, prepared under relevant accounting standards and statements of practice, with the Charity Commission. These financial statements are available in the public domain.

One of the requirements of such accounts prepared under appropriate accounting standards is that they provide full details of all companies in which the university owns an equity investment stake. This disclosure captures USOs generated by the parent university and is a source that is available over a number of years. It will also, of course, include companies that do not meet the definition of USOs such as property management companies, and will need to be compared with other independent sources to ensure that non-USOs are not accidentally included in the final data set.

It is not known that this source of data has ever been explicitly used in any previous academic studies of USOs. This is a particularly useful source as it tracks USOs as they are created and subsequently dissolved as the university accounts are prepared annually. The university's statutory accounts are also prepared by a finance team that is completely independent from the technology transfer team, and are audited and verified by an independent firm of chartered accountants who have no connection with the whole of the university's knowledge commercialisation activities. This source is therefore also a powerful independent and objective source of identification of USOs. University accounts were therefore accessed from the Charity Commission's website.

4.7.2 The university's technology transfer office (TTO)

The technology transfer office at a university is usually primarily responsible for overseeing and facilitating the process of forming USOs and transferring technology derived at the university into the ownership of the company. As such, it will need to maintain records of all the USOs created for administrative purposes. It is therefore the most obvious and potentially easiest place from which to obtain data on the financial performance of USOs, aside from the management team of the USO itself, and this is reflected in many of the current studies to date

in this field of the academic literature which used it as the primary source of data e.g. Oskarsson and Schläpfer (2008), Minshall and Wicksteed (2005).

However, there are some difficulties with obtaining the data from this source, particularly if it is not cross-checked against other sources. TTOs often do not maintain historic data on failed USOs which gives rise to the danger of survivor bias (Shane and Stuart, 2002). In addition, detailed financial records are often not kept over a particularly long period of time due to resource constraints, and changes of personnel at the TTO can also give rise to difficulties with loss of expertise and knowledge relating to USOs (Lawton Smith and Ho, 2006). There may also be legal constraints over the sharing of financial data on USOs with external third parties.

As such, data from this source was treated with caution and cross-checked thoroughly against a number of other sources. The TTO website and other published material were used as well as any other relevant data in the public domain to provide a further list of potential USOs.

4.7.3 Commercial databases

Although there are issues with the quality and accessibility of company data from Companies' House, as already noted, this is still the major source of publicly-available company financial performance data in the UK. All companies are obliged by law to file accounts with Companies' House and the data contained therein is collected by a number of commercial databases, often for the purposes of providing a credit score for a company.

During the course of this work two such databases were used: Experian Corpfin UK and Market IQ. As well as providing the basic balance sheet accounting data from filed company accounts, other documents such as annual returns and liquidation documents may be accessed which were useful in building up a picture of the activity of the company over a period of years. Annual returns detail the shareholders, officers and addresses of the company while liquidation documents provide information as to the actions of a liquidator when appointed to wind up a company. Changes in ownership and details of third party external investment can be obtained from such documents.

The accessing and use of these supplementary documents to create a long term picture of the company has not been used in USO performance studies in the literature to date, particularly in the context of obtaining details of third party external investment. Such data has been very difficult to obtain in previous studies which have usually had to resort to asking the company itself.

Both commercial databases used have a search function that allows for searches to be carried out by shareholder name. This is a useful tool for identifying potential USOs as the name of the relevant university can be used as a search term to identify companies in which it held an equity stake. While not all such companies will be USOs, this at least provides another independent source of companies to cross check against the other data sources.

4.7.4 Specialist databases

The final database used in this work is a specialist database called Spinouts UK, maintained by Young Company Finance, which attempts to list all USOs in the UK. A variety of data sources are

used (although not publicly disclosed) in the preparation of this database, although much of the data is thought to be derived directly from the universities and hence their TTOs. Again, the value of this database is to provide one more data source against which others can be checked.

4.8 Finalising and refining the USO database

Once a population of potential USOs for a university had been collected from each source, they were cross-checked in detail against each of the other sources and any anomalies, where companies appeared in one source but not another, resolved through detailed analysis of all available sources and other public sources of information, including the company's website where appropriate.

Where potential USOs were subsequently discovered as a result of this analysis not to meet the chosen definition of a USO, they were discarded from the database and a reason for exclusion noted. The final database of USOs for the university was then drawn up.

4.9 Collection of performance data

Basic classification data for each confirmed USO was then collected, usually from the commercial databases which reflect the public data held by Companies' House, including:

- the company registration number (to assist in further analysis),
- principal activity, and
- a general sector classification of its activities.

As discussed above, and in line with the research questions of this thesis, the three key performance metrics to be used in this study of USO financial performance at a company level are survival, external investment received and IPO/successful exit achieved.

- Survival data was collected mainly from the commercial database to determine dates of incorporation and dissolution.
- External investment data was collected from all the sources although the company accounting information from sets of annual accounts held on the commercial databases was the key source. The share premium account in the USO's balance sheet was the key source of data for investment received. Investment data collected included the identity of the investor, the amount of investment and the date of investment.
- Where USOs achieved a successful exit for the university, a brief case study of their lifecycle was collected from a variety of sources, including news websites.

4.10 Case study

As previously noted, the focus of this work is on a post-industrial region in the UK: the West Midlands. Universities within the region have grown significantly over the last two decades and generate increasing weath and employment for the region as corresponding large-scale industry has declined. In certain cases they have become key actors in undertaking basic research and development (R&D) work in an academic context, developing new technologies as the

proportion of R&D undertaken on a national level by industry has declined. Such universities are thus prime candidates for generating USOs as they seek to commercialise their technologies and add to the overall economic growth of the region, an effect encouraged by various UK national governments and regional authorities. Of course, there is a wide range of entrepreneurial activity undertaken by universities within the same region, ranging from significant amounts to very little.

Given the novelty of the data collection methodology, it was deemed appropriate to undertake a case study by selecting one university in the region and testing the data sources and analysis proposed, before repeating it for the other regional universities (Jelfs, 2016). The University of Birmingham was selected as an appropriate case study as it demonstrably had developed a technology transfer capability with a separate office and staff. It also publicly highlighted the number of USOs that it had created. Data was therefore collected for this university, a major contributor to the local economy and a 'red brick' Russell Group university with a good research pedigree. Alongside the data, a number of informal conversations were held with the Head of Spinouts and Head of Incubation, as well as USO management, to get a wider picture of the context of USO formation and provide valuable alternative opinions and explanations on trends suggested by the data collected. As a result of both forms of data collection, the approach was deemed to be acceptable and continued for other institutions in the region.

4.11 Analysis of data

Once all the data was collected and refined, the results were first compared for USOs from the universities within the West Midlands region and explanations for the trends observed were sought. Classification data includes the number of USOs created by an institution, the date of formation of each USO and their principal activities. Moving on to the three performance metrics chosen, survival for each USO was evaluated using a range of measures such as the aggregate and timed failure rates for a university (defined in Chapter 7), and measures of the time to failure on a company level, including identifying USOs that fail that attract external investment, linking two of the metrics. External investment was compared using measures such as the proportion of USOs from a university attracting funding, the total amount of funding obtained and the amount per USO, and the types of investor attracted to provide funding. Successful exits were measured as a proportion of USOs created, as well as the financial return to the university.

These performance metrics were then compared against those comparable studies in the literature noted in Chapter 3, across a range of universities and countries, and explanations sought for the trends observed. Where possible, the predictions of the chosen theoretical models of signalling and agency theories are described and compared with the actual results observed, to see if the data and its trends are in line with these predictions. Where they differ, attempts are made to explain the difference using the rich data on performance obtained across the region.

4.12 Summary

This chapter outlines and justifies the predominantly positivist research paradigm in which this study is carried out, as well as the methodology used. A detailed research design has also been constructed, and forms the basis for the range of data collected and analysed in the next chapters. In addition, this chapter identifies why the methodology used is different from that of previous studies and why it is predicted to lead to more accurate results, which can usefully be compared to other studies in the literature. A case study of the University was undertaken to provide validity for the selected approach. Finally, a wide range of supplementary research questions which back up the overarching research question in Chapter 1 has been constructed to provide the basis for a wide-ranging study.

5. Financial Performance Analysis of USOs: A Case Study of the University of Birmingham

5.1 Background

This chapter is a case study of the University of Birmingham (UoB) which is one of the universities situated in the West Midlands. It acts as a pilot study for the main body of this work in two main areas: firstly to apply the proposed research design and methodology from Chapter 4 to test the validity of the data collection techniques in extracting performance metric data, and secondly to make some preliminary observations over whether such data is consistent with the predictions of the theoretical frameworks of signaling theory and agency theory, which were identified in Chapter 3 as of potential relevance for this work.

Data was collected between March 2014 and March 2015, and the findings formed the basis of a peer-reviewed journal paper in the International Journal of Entrepreneurship and Small Business (Jelfs, 2016). In Chapter 6 the sources and methods used in this case study have been replicated for all universities in the same geographical region, the West Midlands, and the results from both chapters are then discussed and analysed in greater depth in Chapter 7.

5.2 Introduction to UoB

UoB has been chosen as the subject of this case study as an example university of the West Midlands region, the geographical area whose universities and USOs are the investigation of this thesis. As an institution, it is also of more general interest as it represents the UK's 'redbrick' universities i.e. the first universities founded after the mediaeval institutions, and defined in greater detail in Chapter 6. It is also a member of the Russell Group, a grouping of the top UK research universities. USO financial performance studies performed in the UK to date have considered Oxford (Lawton Smith and Ho, 2006), Cambridge and London Universities (Minshall and Wicksteed, 2005, Lawton Smith *et al*., 2014), which constitute the elite UK universities with particularly strong and well-funded science departments, from which the majority of USOs are known to originate, as well as larger populations of universities (Mueller (2010), Holi *et al*. (2007)).

This case study will therefore provide an additional perspective on the financial performance of USOs from the next tier of UK universities below the elite, and help to determine whether the USO phenomenon has provided significant benefits to the university. It will also serve to complement a study of the redbrick Queen's University, Belfast by Harrison and Leitch (2010) and provide further evidence as to whether the financial performance of USOs justifies the resources invested in them, although their paper considered only a small number of absolute metrics such as employee numbers to conclude that most USOs were very small, as part of a review of the entrepreneurial system in Northern Ireland, so is not directly comparable with this study.

The UoB was established under its Royal Charter in 1900, incorporating elements of older institutions, and was the UK's first 'redbrick' university. It was named 'University of the Year 2014' in the Times Higher Education Awards and consistently ranks highly in various league tables of UK universities, with student numbers of nearly 30,000. A 2013 report by Oxford Economics noted that the University is a significant employer in the West Midlands region of the

UK, supporting 11,830 jobs in the region (a significant proportion of which are highly skilled), and generated over £1 billion of spending in the local economy.

5.3 Constructing the USO database

5.3.1 Sources of data

Four independent, third party data sources were identified and used to create the USO database, in line with the methodology discussed in Chapter 4:

i) The UoB's annual accounts obtained from the University website covering the years ended 31 July 2001 to 31 July 2013 inclusive. Under UK financial reporting requirements, the UoB is required to prepare and file public accounts, and to disclose, in notes to its accounts, details of any shareholdings it owns in other companies, which will include holdings in USOs.

ii) The website of the UoB's Technology Transfer Office, Alta Innovations, provided details of companies described as USOs with which it had had some involvement. Three different versions of the relevant webpage were accessed and utilised during the course of the study.

iii) Company searches were performed using the Experian Corpfin UK business database, which extracts data from all UK company accounts filed at Companies' House, to identify companies in which the UoB was a current shareholder. A range of search terms derived from the descriptor "University of Birmingham" were used to capture USOs as variations were present in recording the identity of the University as a shareholder in companies' annual returns.

iv) A search of the Spinouts UK database was performed to find all USOs identified as associated with the UoB by this specific database. Spinouts UK is a database compiled and updated by Young Company Finance, which seeks to list all spin offs from UK universities since 2000, obtaining data from a range of sources.

Each of these four sources gave rise to a different population of companies that were potentially USOs. These were cross-checked and amalgamated to form a single set, which is shown below in Table 5.1. The data was then refined through in-depth analysis of each potential USO's historic financial data, primarily in the form of company accounts and annual returns, in order to reject companies that did not meet the chosen definition of a USO. The rationale behind the decision to reject a company as a USO is also given below in Table 5.2.

Company	Website current	Website v1 (old)	Website v2 (old)	Experian	Uni accounts	Spinouts UK	USO?
Bioscience Ventures Limited	Y	Y		Y	Y	Y	Y

Alta Biosciences Limited	Y	Y				Y	Y
Serascience Limited	Y					Y	Y
Linear Diagnostics Limited	Y					Y	Y
PsiOxus Therapeutics Limited	Y	Y		Y	Y		N
The Native Antigen Company Limited	Y	Y		Y	Y		Y
Celentyx Limited	Y	Y	Y		Y	Y	Y
Neuregenix Limited	Y	Y	Y	Y	Y	Y	Y
Cytox Limited	Y	Y		Y	Y		N
Circassia Limited	Y	Y			Y		N
Inanovate Limited	Y	Y	Y		Y	Y	N
Irresistible Materials Limited	Y						Y
Applied Functional Materials Limited	Y	Y	Y	Y	Y	Y	Y
Biowaste2energy Limited	Y	Y	Y	Y	Y	Y	Y
Cambridge Mechatronics Limited	Y	Y			Y		N
Metal Nanopowders Limited	Y	Y	Y		Y	Y	Y
Ad Surf Eng Limited		Y	Y	Y	Y	Y	Y
Interface Spectra Limited		Y	Y		Y	Y	Y
McBurney Limited		Y		Y	Y	Y	Y
The Speech Ark Limited		Y	Y		Y	Y	Y
Birmingham Health Science Devices Limited			Y		Y	Y	Y
Crimson Technologies Limited			Y		Y	Y	N
Health Integration Limited			Y				N

Hybrid Systems Limited			Y		Y		Y
Oral Health Innovations Limited			Y	Y	Y	Y	Y
Ortus Medical Limited			Y		Y	Y	Y
Plasgene Limited			Y		Y	Y	Y
RB Scientific Solutions Limited			Y			Y	N
Stemtrax Limited			Y			Y	N
Astron Clinica Limited			Y		Y		N
CDS Telepath Limited			Y			Y	Y
Entice Technology Limited			Y		Y	Y	Y
Mermaid Diagnostics Ltd			Y		Y	Y	Y
Scyron Limited			Y		Y	Y	Y
The Binding Site Limited			Y			Y	N
Cryo Technology Limited				Y	Y		Y
Prolego Technologies Limited				Y	Y		Y
CPD HQ Limited				Y	Y	Y	Y
Vfridge Limited				Y			Y
Cobra Biomanufacturing Limited					Y		N
Intrec Limited					Y		N
Practice Management Services Limited (Exmet)					Y		N
Hyperspace Ltd					Y		Y

Table 5.1 Potential USOs from UoB identified from the data source

5.3.2 Refining the database

The refining of the raw data obtained from a range of independent sources through extensive analysis of historic financial performance data is a key feature of this study. Previous USO financial performance studies have rarely used independent sources or made detailed attempts to construct a 'narrative' for a company over a long period of time based on analysis of its

historic financial data, backed up by other sources, to decide whether it is a true USO based on the selected definition.

As a result of the refining process, a number of potential USOs were rejected from the final database for a variety of reasons, which may be summarised by the following categories:

i) Companies where the University held an equity stake, but which had been set up by the University for some specific administrative purpose such as management of property rather than transferring and commercialising intellectual property.

ii) Companies which were described by one or more of the sources as a USO but where detailed financial analysis revealed that the University had never held an equity stake. It is possible that some of these companies do meet one of the alternative HEFCE definitions of a USO, such as those companies that were set up by former or current University staff or students, and were assumed or adjudged to be USOs by the creator of the data source, but the extent of university involvement is not recorded in the public domain.

iii) Companies where the University appeared to have acquired a small equity stake some time after its formation but where it did not appear to be the primary source of the company's intellectual property. Clearly a judgment had to be made in removing this kind of company from the database, but the evidence was generally fairly clear cut including cases where the company was clearly a USO associated with another University.

Companies identified as potential USOs by one or more of the sources, but which were rejected from the final data set upon further analysis, are shown in Table 5.2 together with the reasons for rejection.

Refining the data in this way gave a final total population of 29 USOs incorporated between 1987 and 2011. 2001 and 2002 were the most popular years with 4 USOs being incorporated in each, which may be linked to the introduction of UCFs in the UK to encourage USO formation, and at least one USO was formed each year by the UoB between 2000 and 2011 (Graph 5.1). No USOs were formed at all between 1987 and 1997 highlighting the fact that the USO phenomenon is a relatively new one. In addition, no USOs were formed after 2011, which could imply that this route is losing attractiveness as a means of commercialising university technology. The pattern of formation of USOs is discussed in more depth in Chapter 7 along with the results from other USOs in the region.

Company name	**Reason for rejection as USO**
PsiOxus Therapeutics Limited	Hybrid Systems Limited, a UoB USO, was acquired by Myotec Therapeutics Limited, an Imperial College USO via a share for share exchange in 2010 to form PsiOxus. UoB has a small stake in the new company but no management input. The new company is still in the development phase so any realisation of its shareholding is unlikely at present.

Cytox Limited	An Oxford University USO; one of the academic founders moved to a post at UoB which has a very small equity stake in the company, probably as a result of some technology transfer or licensing agreement. Company is based in Oxford.
Circassia Limited	Originally an Oxford/Imperial USO, the company acquired the proprietary technology to ToleroTrans, an organ transplant anti-rejection technology from UoB in 2007 for which it received a small equity stake
Inanovate Limited	UoB holds no shares
Cambridge Mechatronics Limited	UoB holds a tiny equity stake, again most likely from a licensing of technology in the past. Company appears likely to cease trading in the near future meaning the equity stake has no value
Crimson Technologies Limited	UoB holds no shares
Health Integration Limited	Company cannot be found in Experian Corpfin
RB Scientific Solutions Limited	Company dormant until dissolved; UoB had no shareholding
Stemtrax Limited	UoB holds no shares
Astron Clinica Limited	UoB held an equity stake from 2005 although company was founded in Cambridge in 1998, most likely from a licensing of technology. Company has been dissolved.
The Binding Site Limited	UoB holds no shares. The Binding Site was formed in the 1970s by researchers within the Medical School of UoB to develop innovative ways of producing antibodies, but were unable to secure government funding so set up a private company. This is a classic situation that supporters of USOs wish to avoid occurring whereby university-generated IP did not generate a commercial return for the university.
Cobra Biomanufacturing Limited	UoB only had small equity stake taken in 2006; company now dissolved
Intrec Limited	Company was a training consortium and not a USO
Practice Management Services Limited	UoB only ever held less than a 1% equity stake and company was dissolved in 2011

Table 5.2 Rationale for rejection of UoB companies as USOs

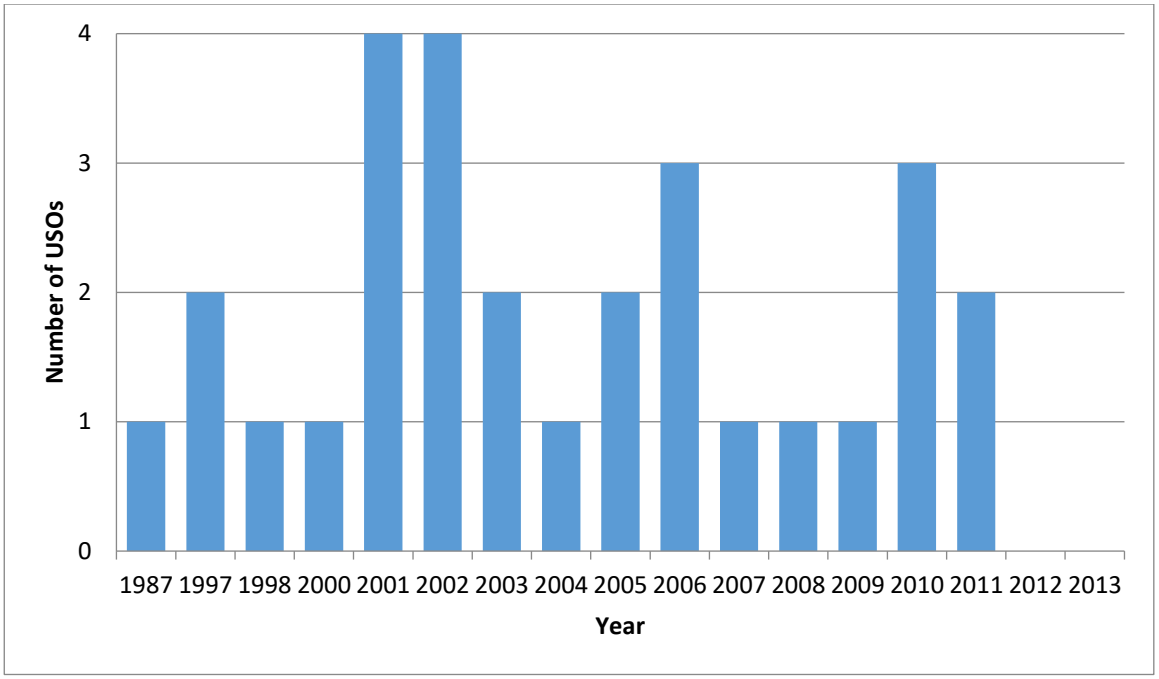


Figure 5.1: UoB USOs, total population, number by year

5.3.3 Independent source validation

In arriving at the final population of USOs, it became clear from Table 5.1 that none of the four sources would have been sufficient by themselves to give an adequate reflection of the true USO population.

Source i) correctly identified 23 USOs, identified 11 companies that turned out not to be USOs and missed 4 USOs (other USOs were outside the date range of the accounts). As a source, it was invaluable in identifying companies where the university had at one time held an equity stake but no longer did so at the date of this study, either through a successful exit such as a trade sale of the shares or, more negatively, the company failing and being dissolved.

Source ii) was the least comprehensive of the sources, with a number of older USOs being missed entirely from the website. None of the three versions of the website was significantly more accurate than the others. This may be due to lack of historical knowledge among the TTO staff concerning the older USOs, or simply a desire to overlook USOs that ultimately failed or had effectively ceased trading. This finding is of particular interest in that a number of previous performance studies relied significantly upon data provided by a university TTO with which to construct a database, although the accuracy of a TTO as a USO data source has already been questioned (Kenney and Patton, 2009). The value of the present study in using a number of independent sources of data is thus emphasised.

Source iii) did not identify cases where the University no longer held an equity stake. However, it was of critical importance in providing the historic financial data with which to determine whether a number of companies met the USO definition. It correctly identified 12 USOs.

Source iv) provided a useful additional corroboration although some USOs were missed and other companies incorrectly identified as USOs. 22 USOs were correctly identified with 5 companies defined as USOs proving not to be.

The combination of these four sources thus provided a comprehensive and extremely accurate database of USOs from which relevant financial performance measures could be obtained.

5.3.4 Financial performance data

This study differs from many previous studies of USOs in the way it collects financial performance data. Following on from Chapter 3, it does not attempt to collect data based on USO turnover or number of employees either by considering absolute values or growth measures, even though these are popular measures in financial performance literature in general and have been used in USO financial performance studies e.g. Harrison and Leitch (2010), Wennberg *et al*. (2011). There are two main reasons for this choice. Firstly, as already noted, this data is not available from independent third party sources which is a key differentiating factor of this study, as previous studies have often had to resort to asking the USOs themselves for such data e.g. Mueller (2010). Secondly, the data gives only a partial picture at best as to the financial performance of a USO in generating value for its shareholders.

As a result, this study focused on collecting performance data based on the key performance metrics discussed in Chapter 3, namely survival, third party investment obtained and IPO/exit. Such metrics have, as previously noted, been widely accepted as suitable by a number of recent studies e.g. Library House (2008).

The following performance data was therefore collected from the above four sources and laid out in the tables below:

1. Basic data
    i) Company registration number
    ii) Principal activity
    iii) SIC code (denotes the directors' evaluation of the company's principal activity and assists in classification)

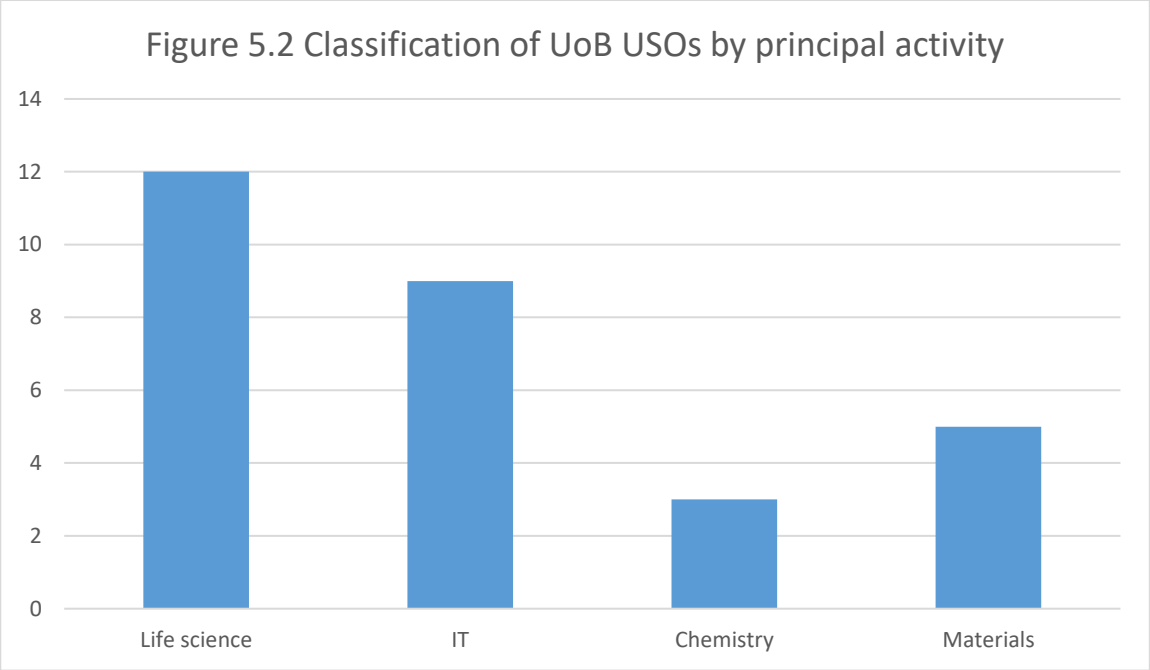
2. Survival measurement
    i) Date of incorporation
    ii) Date of dissolution

3. Investment and exit measurement
    i) Amount of independent third party funding received
    ii) Whether a successful exit was achieved and financial details of the exit

5.4 Results

USO name	Company registration number	Principal activity	Classification
Bioscience Ventures Limited	7384973	Diagnostic development	Life science
Alta Bioscience Limited	7278564	Healthcare	Life science
Biowaste2energy Limited	6477432	Convert waste sugar to energy	Chemistry
CPD HQ Limited	4481112	Dental e-learning	IT
Hybrid Biosystems Limited	3421781	Cancer treatment	Life science
V Fridge Limited	4023297	Software consultancy and supply	IT
Ad Surf Eng Limited	4155505	Surface engineering	Materials
Applied Functional Materials Limited	4562522	Ultrasonic transducer development	Materials
McBurney Scientific Limited	4989529	Soil moisture detectors	Materials
Neuregenix Limited	5332791	Neural tissue screening and consultancy	Life science
Oral Health Innovations Limited	6033739	Licenses dental software	IT
Prolego Technologies Limited	5494857	Develop network analysis tool	IT
Scyron Limited	4341195	Software development	IT
Celentyx Limited	5304904	Drug development service	Life science
Interface Spectra Limited	6422685	Spectroscopy	Chemistry
Metal Nanopowders Limited	4562587	Manufacture metal powders	Materials
The Speech Ark Limited	5686224	Speech technology	IT
Linear Diagnostics Limited	7582291	Detect infectious agents	Life science
Serascience Limited	7591669	Cancer diagnostic	Life science
Irresistible Materials Limited	6847082	Develop novel fullerenes	Materials
Birmingham Health Science Devices Limited	4923889	Devices for wound assessment	Life science
Ortus Medical Limited	4562564	Develop biomaterials	Life science
Plasgene Limited	5812161	Bacterial plasmid research	Life science
CDS Telepath Limited	2128488	Computer turnkey solutions for laboratories	IT
Entice Technology Limited	4239448	Deliver road weather information (software)	IT
Mermaid Diagnostics Limited	3638617	Design clinical diagnostic devices	Life science
Hyperspace Limited	3435052	Software development	IT
The Native Antigen Co Limited	7386339	Antigen R&D	Life science
Cryo Technology Limited	4265434	Cryogenic technology development	Chemistry

Table 5.3 Basic classification of UoB USOs



USOs seeking to commercialise technologies within the fields of life sciences and IT (information technology) comprise the vast majority of those originating from the UoB, a feature commonly observed in studies at other universities e.g. Lawton Smith and Ho (2006), Oskarsson and Schläpfer (2008).

5.4.1 Survival measurements

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Ad Surf Eng Limited	7/2/01			
Alta Bioscience Limited	9/6/10			
Applied Functional Materials Limited	15/10/02			
Bioscience Venture Limited	22/9/10			
Biowaste2energy Limited	18/1/08	20/5/14	76	Y
Birmingham Health Science Devices Limited	7/10/03	20/10/09	72	N
CDS Telepath Limited	6/5/87	11/6/02	181	N
Celentyx Limited	6/12/04			
CPD-HQ Limited	9/7/02	5/5/09	81	Y
Cryo Technology Limited	6/8/01	17/7/07	71	Y
Entice Technology Limited	22/6/01	18/10/11	123	N

Hybrid Biosystems Limited	19/8/97			
Hyperspace Limited	16/9/97	31/7/01	46	Y
Interface Spectra Limited	9/11/07	1/10/14	82	N
Irresistible Materials Limited	16/3/09			
Linear Diagnostics Limited	29/3/11			
McBurney Scientific Limited	9/12/03	15/7/14	127	Y
Mermaid Diagnostics Limited	25/9/98			
Metal Nanopowders Limited	15/10/02			
Native Antigen Company Limited	23/9/10			
Neuregenix Limited	14/1/05			
Oral Health Innovations Limited	20/12/06			
Ortus Medical Limited	15/10/02			
Plasgene Limited	10/5/06			
Prolego Technologies Limited	29/6/05	18/11/08	40	Y
Scyron Limited	17/12/01	1/10/11	117	Y
Serascience Limited	5/4/11			
The Speech Ark Limited	24/1/06			
Vfridge Limited	28/6/00	28/9/04	51	Y

Table 5.4 Survival data for UoB USOs

As noted above, 29 USOs in total were identified with dates of incorporation ranging from 1987 to 2011. Even where a USO has been formally dissolved, the UoB is still shown as a shareholder on Experian Corpfin (source iii), providing a powerful validation that older USOs were not missed as a matter of routine in the study. Of the 29 USOs identified, 12 had been formally dissolved. This represents an aggregate failure rate of 41%.

Oskarsson and Schläpfer (2008) identify two methods for calculating failure rates which have been studied in the literature and will be used here. The 'aggregate failure rate' is the total number of failed USOs by the end of the study period's last year divided by the total number of USOs created during the study period. This measure clearly does not consider the age of the USO and is therefore difficult to compare effectively with other studies. The second method is the 'timed failure rate' which refers to the percentage of USOs that fail within a specific number of years from incorporation and thus better reflects the age factor. Table 5.5 below shows the timed failure rate of the 29 UoB USOs. The average time to failure of the 12 dissolved companies was 89 months and ranged from 40 months to 181 months.

Years to failure Incorporated	1	2	3	4	5	6	7	8	9	10	11	12	15
1987	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
1997	0%	0%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1998	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2000	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	
2001	0%	0%	0%	0%	0%	25%	25%	25%	25%	75%	75%	75%	
2002	0%	0%	0%	0%	0%	0%	25%	25%	25%	25%	25%	25%	
2003	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	100%		
2004	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
2005	0%	0%	0%	50%	50%	50%	50%	50%	50%				
2006	0%	0%	0%	0%	0%	0%	0%	0%					
2007	0%	0%	0%	0%	0%	100%	100%						
2008	0%	0%	0%	0%	0%	100%							
2009	0%	0%	0%	0%	0%								
2010	0%	0%	0%	0%									
2011	0%	0%	0%										

Table 5.5: UoB spin offs: timed failure rates (author-derived data)

5.4.1.2 'Twilight' USOs

During the collection and analysis of the data it became clear that a number of USOs, although not formally dissolved, had minimal trading activity. This study designates this important group of companies as 'twilight USOs'. While an element of judgment has to be made as to whether a company has reached 'twilight' stage, a further 8 companies (29% of the sample) were identified as twilight USOs. The population's total effective aggregate failure rate is thus 69% (20 out of 29 USOs). Table 5.6 below reveals the identity of the twilight USOs, as well as the rationale behind their designation as such. Typical attributed of a twilight USO include minimal trading activity and no external funding received, or received many years previously.

Twilight USOs are an important concept for the USO literature, as similar entities have already been discussed and studied in the wider literature. These have been given a range of names, including 'living dead' companies (Ruhnka *et al*., 1992) and 'zombie' companies (Hoshi, 2006), although the latter designation has often been used in the specific case of companies that are so highly leveraged that they can barely afford to pay the interest on their loans. This concept has not been explored in any significant depth in the existing USO literature although certain studies have commented in a broad manner on the phenomenon e.g. Royal Society of Chemistry (2005), which applied Ruhnka *et al*.'s (1992) descriptor of 'living dead' to a group of chemistry-based USOs, and de Cleyn (2011) who identified the concept in a wider study of European USOs. Steinberg (2014) noted the concept of 'not successful' USOs, which has a similar rationale. It may be of potential interest in interpreting phenomena such as the apparent long survival times for USOs compared to other start-up companies (Zhang, 2009). Data on twilight USOs has been collected from the other West Midlands universities to allow analysis to take place on a wider scale in Chapter 6.

USO	**Rationale for 'twilight' designation**
Ad Surf Eng Limited	No funding ever received – has developed into a profitable consulting company – little activity
Applied Functional Materials Limited	Last funding in 2006 – very little activity
Celentyx Limited	Last funding 2009 – very little activity
Metal Nanopowders Limited	Last funding 2006 - consultancy company with little trading
Neuregenix Limited	No funding – consultancy company
Oral Health Innovations Limited	Not for profit joint venture with PreVis – no funding
Ortus Medical Limited	No funding – little activity
Plasgene Limited	No funding – little activity

Table 5.6: Rationale for 'twilight' designation

5.4.1.3. Analysis of survival data

While analysis of survival data will be performed on a regional basis in much greater depth in Chapter 7, preliminary analysis of the UoB data shows some interesting trends that merit further investigation. Oskarsson and Schläpfer (2008) note the lack of academic studies in general providing data on the failure rates of generic early stage venture capital supported companies. Metrick (2007) undertook an extensive study of the Sand Hill Econometrics (SHE)

database and determined the 'timed' failure rate after 10 years to be in the region of 30-40%. Dean and Giglierano (1990) studied 38 Silicon Valley–based venture capital funds reporting an aggregate failure rate of 15-16% while Mason and Harrison (2001) reported an aggregate failure rate of 34% in their study of 127 early stage investments by UK business angels.

In comparison with USOs, one might expect the USO failure rate to be higher than these studies given that only a proportion will be successful in attracting venture capital funding. This does presume that venture capitalists are inherently more likely than not to support a company that is less likely to fail, and would be in line with the predictions of signaling theory in that USOs which could send out positive signals e.g. about the strength of their technology, to a prospective investor, are more likely to attract funding and hence survive for longer than companies which do not. Zhang (2009) found much higher rates of survival among venture capital-backed USOs than more generic venture capital-backed companies although the reasons for this are disputed. Cressy (2006) notes that a number of studies of all startups show that about 50% fail within two and a half years of staring to trade, which is clearly sugnfucantly faster than for USOs. However, the current study appears to show much higher failure rates than these earlier studies from the venture capital literature, in contrast to earlier studies.

In this study of the UoB, eight of the dissolved USOs had attracted third party funding. In addition, three of the twilight USOs had attracted third party funding. This overall equates to 55% of the failed USOs, and is in line with the 48% (14 out of 29) of the total population of USOs that attracted external funding. Hence, third party funders have not, for this small sample, shown a superior judgment of a USO's survival prospects in assessing which USO to fund.

Comparison of UoB's USOs' survival rates with existing academic studies of USO financial performance reveals a number of interesting findings. Previous studies have considered survival rates at both a country and university level (Tables 5.7 and 5.8). In general, it is clear that this study shows a lower rate of survival amongst USOs than most other studies when considering only formally dissolved USOs (59%), and a significantly lower rate than all other studies in Tables 5.7 and 5.8 below if 'twilight USOs' are included (31%), which again implies that 'twilight USOs' are an important class of USO that may shed some light upon the apparent longevity of USOs compared to other start-up companies as noted in the academic literature to date. Tables 5.7 and 5.8 show a wide range of survival rates, which again highlights the care that needs to be taken in comparing studies, particularly around different definitions of USOs.

When comparing UoB's survival rates against the other single university studies in Table 5.8, the lower survival rates are again potentially consistent with signaling theory in that the UoB is not as prestigious a research institution as MIT, Oxford or ETH Zurich, so on first principles its technologies would be less strong, and when coupled with its lower prestige, give out less attractive signals to investors and attract less finance, leading to shorter survival times. Agency theory might predict a lack of goal congruence between TTO and investor where technology appears weak, leading to a lack of further investment and lower survival times. Such a hypothesis is only a preliminary judgment and will be considered further in Chapter 7. Studies on a country basis are more difficult to compare due to the range of universities contained therein.

Country	Survival rate (%)	Period	Years	Sample size	Source
USA	68	1980-2000	21	3376	Shane (2004)
Canada	73	1995-2003	9	301	Clayman and Holbrook (2006)
Hong Kong (timed rate after 5 years)	79	1997-2004	8	56	Leung and Mathews (2011)
Netherlands	83	1984-1992	9	92	Shane (2004)
France	84	1984-1987	4	100	Mustar (1997)
Sweden	87	1960-1993	34	30	Shane (2004)
Northern Ireland	94	1984-1995	12	17	Shane (2004)
Sweden (timed rate after 2 years)	73	1994-2002	9	528	Wennberg *et al.* (2011)
Sweden (timed rate after 5 years)	53	1994-2002	9	528	Wennberg *et al.* (2011)
USA	94	1991-2001	11	655	Zhang (2009)
UK	>90	1998-2002	5	174	Minshall and Wicksteed (2005)
UK	57	2003-2010	8	2,356	HEFCE
UK	59	1987-2013	15	29	Current study
UK	31	1987-2013	15	29	Current study (including twilight USOs)

Table 5.7: USO Survival data by country (Oskarsson and Schläpfer, 2008) and current study (excluding 1987 outlier)

University	Survival rate (%)	Period	Years	Sample size	Source
USA – MIT	80	1980-1996	17	134	Shane (2004)
Oxford	90	1950-2004	55	64	Lawton Smith and Ho (2006)
ETH Zurich	88	1998-2007	10	130	Oskarsson and Schläpfer (2008)
UK	59	1987-2013	15	29	Current study
UK	31	1987-2013	15	29	Current study (including twilight USOs)

Table 5.8: USO Survival data by University (Oskarsson and Schläpfer, 2008) and current study (excluding 1987 outlier)

5.4.2 Third party investment results

Table 5.9 below shows which of the UoB USOs obtained external third party funding and the amount of such funding received by each company. The data on funding was obtained primarily from analysis of USO statutory accounts, particularly from review of the share premium account movements, which represent the excess amount of the total investment by an investor over the nominal value of the share capital acquired.

This is a very different approach from other studies to date which attempted to measure funding by approaching the USO directly for information e.g. Mueller (2010) or by reviewing external press releases, often issued by the investor. The approach in this work is considered to be much more accurate as it only records money actually received by the USO and does not rely on individuals' memories or press statements which may be misleading. In addition, a number of deals do not publically disclose the total amount of money invested, particularly where the investor is a larger company and the deal deemed confidential, and data on older deals may no longer be in the public domain.

USO	Investment received	Amount (£)
Ad Surf Eng Limited	N	
Alta Bioscience Limited	N	
Applied Functional Materials Limited	Y	78,557
Bioscience Venture Limited	Y	360,000
Biowaste2energy Limited	Y	139,993
Birmingham Health Science Devices Limited	N	
CDS Telepath Limited	N	
Celentyx Limited	Y	230,842
CPD-HQ Limited	Y	148,500
Cryo Technology Limited	Y	250,000
Entice Technology Limited	N	
Hybrid Biosystems Limited	Y	900,019
Hyperspace Limited	Y	250,000
Interface Spectra Limited	N	
Irresistible Materials Limited	Y	403,947
Linear Diagnostics Limited	N	
McBurney Scientific Limited	Y	42,000
Mermaid Diagnostics Limited	N	
Metal Nanopowders Limited	Y	205,137
Native Antigen Company Limited	Y	508,971
Neuregenix Limited	N	
Oral Health Innovations Limited	N	
Ortus Medical Limited	N	
Plasgene Limited	N	
Prolego Technologies Limited	Y	39,632
Scyron Limited	Y	1,156,924
Serascience Limited	Y	986,760
The Speech Ark Limited	N	
Vfridge Limited	Y	173,250

Table 5.9: Third party investment attracted by UoB USOs

14 out of 29 USOs received external third party investment which represents 48% of the total population. A total of £5,365,569 of investment was received from third parties which aimed to commercialise UoB IP, and the overall level of funding received is compared to universities from other countries in Chapter 8. Table 5.10 provides more detail on the identities of the investors.

USO	University Challenge Fund (Mercia Fund)	Other private equity	Companies	Individuals	Other	Detail
Applied Functional Materials Limited					Y	University of West of Scotland
Bioscience Venture Limited			Y			Joint venture between Abingdon Health Limited and UoB
Biowaste2energy Limited			Y			Modern Waste Limited
Celentyx Limited	Y					
CPD-HQ Limited	Y					
Cryo Technology Limited	Y		Y			Mercia and Cryo Services Limited
Hybrid Biosystems Limited	Y			Y		
Hyperspace Limited			Y			Global Service Investments Limited
Irresistible Materials Limited		Y		Y	Y	Mercia Fund Management, business angels and the Technology Strategy Board
McBurney Scientific Ltd				Y		
Metal Nanopowders Limited		Y				Oxford Technology VCT
Native Antigen Company Limited	Y				Y	Mercia and Cancer Research UK
Prolego Technologies Ltd			Y			Ideas Network Limited
Scyron Limited	Y		Y	Y	Y	Mercia, Dataset Communications Limited, AEGF, NESTA, individuals
Serascience Limited		Y		Y		Thornapple LLP and individuals
Vfridge Limited	Y					

Table 5.10 Identities of external investors in UoB USOs

Given the number of investors and funding rounds, it was not always possible to identify the amount invested by each individual investor as such data was not publicly available.

The Mercia Fund, which was a University Challenge Fund set up by the UK government to provide early stage funding to USOs (see earlier chapter for more details) was unsurprisingly the most regular investor, acquiring equity stakes in seven of the USOs. It might be supposed that UCFs would be less likely to be concerned about the ultimate survival and success of a USO than an investor who was looking for a financial return, given its nature as a publicly funded body set up specifically to provide funding to a narrow group of target companies. The relative success of the Mercia Fund's investments is shown below in Table 5.11.

USO	**Dissolved**	**Twilight USO**	**Still trading**	**Successful exit**
Celentyx Limited		Y		
CPD-HQ Limited	Y			
Cryo Technology Limited	Y			
Hybrid Biosystems Limited				Part of PsiOxus
Native Antigen Company Limited			Y	
Scyron Limited	Y			
Vfridge Limited	Y			

Table 5.11 Mercia Fund investments in UoB USOs

One out of the seven investments could be judged a partial success, although as noted above there is little prospect of any imminent realisation of any value of the equity stake in PsiOxus.

The amounts of investment secured and range of investors show some consistency with the predictions of both signaling and agency theory. The UoB, as a Russell Group university, is regarded as a significant research university which sends a strong signal to potential investors over the attractiveness of its USOs, hence the significant proportion of USOs that attract funding and the wide range of investors. This latter observation is also in line with agency theory which predicts that trust will build between university TTOs and investors once an investment has been secured and both sides realise that their goals of USO success are aligned. However, it should also be noted that that not all USOs obtain funding, which is in line with agency theory where the significant information asymmetry present in the case of a USO and potential investor will inhibit investment, even where the strength of the parent university and its TTO send a strong signal, thus highlighting the conflict between the two factors.

5.4.3 USOs achieving an exit

As already noted, an important goal of a USO created to commercialise university technology is to achieve a financial return for the university by an exit from the company, via a public listing of shares or other form of share disposal such as a trade sale. Of the 29 UoB USOs, only 2 led to an exit for shareholders via a trade sale of the entire share capital to a third party. None of the USOs offered any shares to the public via a stock market listing.

A detailed analysis of the history of the two USOs was undertaken through review of their financial accounts and other publicly available information to provide more details about the nature of the trade sale and whether the terms of the sale were beneficial to the UoB.

5.4.3.1 Mermaid Diagnostics Limited

This USO was founded in 1998 with the aim of commercialising UoB technology in the field of smoking diagnostic testing designed by a UoB academic Graham Cope. The UoB transferred relevant IP to the company in exchange for £83,750 of share capital, although the company received no other external funding.

In 2006 the entire share capital of the company was sold to Personal Screening Plc. The total consideration was £75,000 which consisted of £35,000 of cash and £40,000 of shares in the acquiring company. UoB received its share of both elements of the consideration in line with the other equity investors in the company. Personal Screening Plc subsequently ceased trading meaning that UoB realized no value on the share portion of the consideration, and £12,342 represented its share of the cash portion.

At the date of sale the USO had net assets of £18,553 and a deficit on its profit and loss reserve of £370,518, so the technology in the USO was clearly not at a stage of development to generate profits. This was ultimately reflected in the low sale price which only repaid the original investors, including UoB, a small part of their investment.

5.4.3.2 Entice Technology Limited

This USO was founded in 2001 to commercialise software developed at UoB. The software predicted road, rail and runway conditions which allowed local councils to decide when to salt or grit roads, predicted when rail routes might suffer after icing or buckling and when runways were unsafe to land on. The UoB transferred IP to the company in exchange for 57,500 ordinary 1p shares i.e. the IP was valued at £575. The company did not receive any other funding.

In 2006 the entire share capital of the company was acquired by Weather Services International Limited for £839,000 in cash, and in line with the other equity investors, UoB received £482,425 in return for its stake. At the date of acquisition, the company had net assets of £50,088 and a profit and loss reserve of £49,088, showing that it was already a profitable company at this stage.

To date, this is the single example of UoB making a financial return on its equity stakes in all of its USOs. Agency theory is of relevance in explaining this low level of performance with the significant information asymmetry present in the case of USO and potential investment, meaning that despite the scale and range of investment obtained by UoB USOs, in general investment decisions by external parties were poor ones, particularly as the only ‘successful’ USO did not obtain any external

funding. This lack of quality of underlying technology proved critical in the exit outcomes, despite the apparently strong signals that the UoB could send out based on its research strength.

5.5 Discussion of the performance data

While the focus of this chapter is largely to validate the proposed methodology from Chapter 4 to collect relevant data, some preliminary discussion of the financial performance data of the USOs has been included at this stage. The data from UoB will be analysed in much more detail in Chapter 7 alongside that collected from all other universities in the West Midlands region.

5.5.1 Survival results

Analysis of the survival results obtained leads to some interesting discussion points. The data on survival of USOs identifies clearly a concept not discussed in great depth to date in the academic literature on financial performance of USOs, namely a class of USO that has not secured any funding for a period of time and has effectively ceased trading but has not been formally dissolved. These have been designated 'twilight USOs' in this study.

It has long been received wisdom that USOs survive longer than other start-up high-tech companies (Shane, 2004; Zhang, 2009). Other USO performance studies have shown extremely high survival rates among USOs, even after significant periods of time have elapsed (Tables 5.7 and 5.8). However, it is clear that these studies only considered USOs that had been dissolved. The existence of twilight USOs could significantly change this analysis as they represent companies that have effectively failed and are unlikely to lead to any financial return for the university. In this small sample of USOs, as already noted 41% had been formally dissolved with a further 29% of the sample being designated as twilight USOs. However, this sample clearly includes USOs that have only recently been formed and have not had time to fail. Given that 5 USOs which were still surviving in 2014 were formed in 2010 and 2011, among the older USOs the failure rate will be significantly higher even than these headline figures.

Analysis of the twilight companies shows a range of companies, some of which obtained external funding and some of which did not. In most cases, the technology transferred from the UoB does not appear to have reached a stage at which it can be commercialised, and the company has effectively ceased operations, possibly in hope of future funding. Where a company has obtained funding in the past, a significant gap since the last funding date is indicative of a 'twilight USO'. Other companies in the set appear to be moderately profitable consulting companies, which may have originally been set up for this purpose, or gradually moved towards this form of activity when an early stage technology did not appear to be readily commercialisable. The set of 'twilight' USOs is small and further study of similar companies at other universities will be undertaken. It should also be noted that twilight USOs may start trading again for a range of reasons such as technology becoming more useful, although this situation is not observed in this work.

Consideration also needs to be given as to the reasons why USOs appear to survive longer than other high-tech start-up companies. USOs contain IP transferred from the university, so it may be preferable for the university and any external funders to keep the company alive in the hope that the IP may have some value to a third party, especially if the running costs of the company are low. For non-USOs, the owners may have shorter timescales, especially where there are no external funders and hence no funders and hence no cash to cover ongoing running costs. This is likely to be a better explanation than some of the reasons given in the existing literature e.g. Zhang (2009).

5.5.2 External investment results

A number of positive financial indicators related to external investment have been identified. USOs from the UoB attracted over £5 million of external funding to develop UoB technology, and almost 50% of the USOs secured external funding. A wide range of external investors were attracted to the prospect of the USOs' technologies to provide such funding. While the financial results for the UoB are mixed, as discussed in the next section, such funding will have at least maintained skilled jobs within the region and may have given rise to new IP amongst USO employees and companies in their supply chains. It should also be noted that it is perfectly normal for investors, even highly sophisticated ones, in any start-up companies to see the majority of their investments fail due to the inherently risky nature of the companies. Statistics such as survival data and attraction of external investment must therefore be analysed and interpreted with great care, and the additional, non-financial benefit to a university must be considered too. USOs provide only a limited view of university knowledge spillover (Lester, 2005; Ortin-Angel and Vendrell-Herrero, 2014), which is likely to have been relevant for the regional UCF (the Mercia Fund), which saw little financial return on its investments. However, financial performance data such as those in this study should play a key part in the decision of a university to establish or retain a USO programme when compared to other means of exploiting its IP.

In addition, any conclusions based on such a small set of data must be interpreted with great care especially as it is from a single university which may have a different USO creation policy from other universities. The results from this study do back up those of Harrison and Leitch (2010) which questioned the value of a USO programme to another "redbrick" university. However, it is equally clear that other UK universities have generated significant amounts of money through the successful exit from USOs. Data from many more universities will need to be collected and analysed to test the validity of the results of this study, and this will be undertaken during the subsequent chapter where all universities within the West Midlands region are studied.

5.5.3 Exit results

None of the UoB's 29 USOs achieved an IPO during the period under review (Bonardo *et al.'s* (2011) 'crowning achievement' for a USO), and only two reached an exit via a trade sale, of which only one can be deemed a financial success. Such a return is likely to have been a major disappointment given the length of time of the USO programme and the amount of third party investment obtained. In addition, it compares unfavourably with other UK universities such as Oxford (Lawton Smith and Ho, 2006) where USOs reached IPO stage. Overall, the UoB cannot be said to have gained financially from its USO programme, given the ongoing costs it incurred in running its technology transfer operations over the period. Chapter 7 will detail whether this experience was a common one throughout the region.

5.6 Conclusion

Overall, this case study has been a success in that it validates the data collection techniques proposed in Chapter 4. Using four independent sources of data produced an accurate dataset and clearly highlighted the inadequacies of using a single source. A stringent refining process was needed to remove companies that appeared potentially to be USOs, but in fact were set up for some function other than to commercialise technology. Given the quantity and quality of data collected,

this proved relatively straightforward, although the process was time-consuming. In addition, some preliminary observations were made about the consistency of the data with the theoretical frameworks of signaling and agency theory, as chosen in Chapter 3.

Survival, investment and exit data were collected and a very brief analysis of such data was performed. Even at this early stage of the overall work, interesting observations were made such as the potential identification of a class of USO which was designated 'twilight USOs' and which may offer an explanation to the long-held view that USOs survive for longer than other high-tech startup companies. In addition, two short histories of the only two USOs to achieve any form of exit were constructed using solely the financial data available from the sources.

In addition, further information was obtained of wider interest to USOs from the sources. The Binding Site is a hugely successful company which was based on UoB technology, but the UoB never held any equity stake in the company as the inventor academics had to attract external finance to commercialise their technology, so did not benefit financially from its success. These events took place many years before the UK's recent policy focus on USOs, and is a clear indication of some of the motivations behind such a programme; namely, to ensure that universities obtain some financial benefit from their commercialisable technology. Unfortunately, the subsequent USO programme seems to have largely failed to achieve this, with only one financially successful exit meaning that the UoB has not secured any lasting financial benefits.

Given the success of this case study, its data collection methods and consistency with theoretical frameworks will now be applied with confidence to the other universities within the region in the following chapter.

6. Financial Performance Data from Spin Off Companies from other West Midlands universities

6.1 Background

Following the conclusion of the case study performed for the UoB in the previous chapter, similar financial performance data was collected from all other universities located in the West Midlands area and some preliminary observations made, as for UoB, over the consistency of the data with signaling and agency theories. Data were collected between March 2014 and March 2015 for the twelve universities based in the West Midlands, which are identified as those represented by 'Universities West Midlands', a not-for-profit organisation which supports its constituent members, namely:

Aston University

University of Birmingham

Birmingham City University

University College Birmingham

Coventry University

Harper Adams University

Keele University

Newman University

Staffordshire University

University of Warwick

University of Wolverhampton

University of Worcester

In order to provide some structure to this chapter, these universities can be classified together into different groups, based to some extent on their date of obtaining university status. This provides an additional level of analysis to enable comparisons to be made between financial data from different types of universities. A number of classifications are in general use, and those of relevance to the West Midlands are Russell Group universities, Plate Glass universities and Post-92 universities.

Sometimes referred to as Plate Glass universities, a number of universities gained their status during the 1960s, many of which were previously Colleges of Advanced Technology. These include Aston University (formerly Birmingham College of Advanced Technology) and Keele (formerly North Staffordshire University College).

Post-92 universities refer to academic institutions granted university status in the UK through the Further and Higher Education Act of 1992, as well as those granted university status since 1992 without receiving a royal charter. Of the West Midlands universities, four are Post-92 universities with polytechnic roots, namely Coventry University (formerly Lanchester Polytechnic then Coventry Polytechnic), Birmingham City University (formerly Birmingham Polytechnic), Staffordshire University (formerly Staffordshire Polytechnic) and Wolverhampton University (formerly Wolverhampton Polytechnic). Those that fall into the second category are the University of Worcester (formerly Worcester College of Higher Education), University College Birmingham, Harper Adams University (formerly Harper Adams University College) and Newman University (formerly Newman College of Higher Education).

The Russell Group has already been mentioned, and this includes Birmingham and Warwick from this sample. Birmingham is also often referred to as a 'redbrick' university, which is a term sometimes used to describe nine civic universities founded in major industrial cities of England during the 19th and early 20th century.

It can therefore be seen that a wide range of universities exist in this single region, and the USO formation and performance may therefore reflect this diversity (Steinberg, 2014). It is clear from the outset that the Post-92 universities have only participated in the USO phenomenon to a minor extent, with none of the universities in the region which were not former polytechnics creating any USOs at all. This is likely to be related to the observation that most USOs come from science or technology departments, which require heavy investment to maintain and are not featured significantly among those less research-oriented institutions. In simplistic terms, one would expect to see USOs showing stronger financial performance from more research-focused universities, which for this sample would be in descending order: Russell Group, Plate Glass, Post-92. Whether this is seen in practice will be an important part of this work, and given that single UK university studies in the existing literature are scarce (Oskarsson and Schläpfer, 2008), this work will make an important addition to those studies.

6.2 Plate Glass universities - Aston and Keele

Aston University (Aston) received its Royal Charter in 1966, although it was originally founded as far back as 1895 as the Birmingham Municipal Technical School, which was later transformed into the College of Advanced Technology. Its history reflects its status as a research-led university with a bias towards technology, and it currently hosts about 12,000 students. Interesting comparisons can be drawn with the UoB as Aston achieved university status more recently, and is not a member of the research-led Russell Group, although its historical bias towards technology as noted above is one of the academic areas in which USOs are prevalent. It will be revealing to see whether this difference is reflected in the financial performance of its USOs.

Keele University (Keele) received its Royal Charter in 1962, although it was originally founded as the University College of North Staffordshire in 1949. The new university attempted to break away from the pattern of the specialised honours degree, and most students read four subjects in their degree course, two at honours level and at least two as a subsidiary. At least one of these subjects had to be from the arts or social sciences, and at least one from the natural sciences. Until the 1990's most students followed a unique four-year course, beginning their studies with a Foundation Year, which was a broad course covering the development of Western civilisation through the perspective of almost every academic subject. Keele currently hosts about 10,000 students.

6.2.1 Constructing and refining the USO database

Three independent, third party data sources were identified and used to create both the Aston USO and Keele USO database, in line with the methodology discussed in the previous chapter. Unlike the UoB, neither Aston nor Keele had a dedicated technology transfer website listing out potential USOs. The three are:

i) Annual accounts obtained from the relevant University website covering the years ended 31 July 2002 to 31 July 2013 inclusive for Aston and 31 July 2005 to 31 July 2013 for Keele.

ii) Company searches were performed using the Experian Corpfin UK business database which provides data from all UK company accounts filed at Companies' House, to identify companies in which Aston or Keele was a current shareholder. A range of search terms derived from the descriptors "University of Aston" and "Keele University" was used to capture USOs as variations were present in recording the identity of the University as a shareholder in the companies' Annual Returns.

iii) A search of the Spinouts UK database was performed to find all USOs identified as associated with Aston and Keele by this specific database.

As with the UoB, each of these three sources gave rise to a different population of companies that were potentially USOs. These were cross-checked and amalgamated to form single sets, which are shown below in Tables 6.1 and 6.2. The data was then refined through in-depth analysis of each potential USO's historic financial data, primarily in the form of company accounts and annual returns, in order to reject companies that did not meet this study's chosen definition of a USO.

Company	**Experian**	**University accounts**	**Spinouts UK**	**USO?**
Academy Optics Limited	Y		Y	N
Aerbuddies Limited	Y	Y	Y	Y
Applied Search Technology Limited			Y	N
Astals Training Limited	Y	Y	Y	N
Astasense Limited			Y	N
Astelics Limited		Y		Y
Astisen Limited	Y	Y		N
Aston Business Assessments Limited	Y	Y	Y	Y
Aston Molecules Limited			Y	Y
Aston Organisation Development Limited			Y	N
Aston Student Limited	Y	Y	Y	N
Halsa Pharmaceuticals Inc			Y	N

Aston Photonic Technologies Limited		Y	Y	Y
Midland Pharma Training Limited	Y		Y	N
Protomax Limited	Y	Y	Y	Y
Sapere Systems Limited	Y	Y	Y	Y
X-link Limited			Y	N

Table 6.1 Potential Aston USOs identified from the data sources

Company	**Experian**	**University accounts**	**Spinouts UK**	**USO?**
Intelligent Orthopaedics Limited	Y	Y	Y	Y
SciCorr Limited	Y	Y	Y	Y
Prescribing Decision Support Limited	Y	Y	Y	Y
nanoTherics Limited	Y	Y	Y	Y
MagneCell Limited	Y	Y	Y	Y
Mica Biosystems Limited			Y	N
SciSite Limited	Y	Y	Y	Y

Table 6.2 Potential Keele USOs identified from the data sources

Companies identified as potential USOs by one of the sources, but which were rejected from the final dataset upon further analysis, are shown in the following tables (Tables 6.3 and 6.4) together with the reasons for rejection.

Company name	**Reason for rejection as USO**
Academy Optics Limited	Company dormant since incorporation and now dissolved; Aston owned 100% of the shares
Applied Search Technology Limited	Aston never held an equity stake – may have been a start-up company
Astals Training Limited	Company dormant since incorporation and now dissolved; Aston owned 100% of the shares
Astasense Limited	Company formed by Aston academics; Aston never held an equity stake i.e. likely to be a start-up rather than a USO
Astisen Limited	Company dormant since incorporation and now dissolved; Aston owned 50% of the shares
Aston Organisation Development Limited	Company formed by Aston academics; Aston never held an equity stake i.e. likely to be a start-up rather than a USO
Aston Student Limited	Company dormant since incorporation; Aston owned 100% of the shares
Halsa Pharmaceuticals Inc	An American company funding Aston research – no UK company hence not a USO
Midlands Pharma Training Limited	Company dormant since incorporation and now dissolved; Aston owned 50% of the shares
X-link Limited	Start-up formed by Aston academic

Table 6.3 Rationale for rejection of companies as Aston USOs

Company name	Reason for rejection as USO
Mica Biosystems Limited	Company based on University technology but Keele holds no shares

Table 6.4 Rationale for rejection of companies as Keele USOs

Refining the data gave a final total population for Aston of 7 USOs incorporated between 1983 and 2010, and 6 for Keele between 2002 and 2011. 2007 and 2010 were the most popular years for Aston with 2 USOs being incorporated in each (Figure 6.1), while Keele never formed more than one USO in a year (Figure 6.2). No USOs were formed at all before 2000 highlighting the fact that the phenomenon of significant increase in creation of USOs is a relatively new one. In addition, as with the UoB, no USOs were formed after 2010, which could imply that this route is losing attractiveness as a means of commercialising university technology. Unlike UoB, however, there is no discernible pattern in terms of increasing or decreasing numbers of USOs, and numbers overall are much lower. Aston and Keele may have had less enthusiasm for setting up USOs over the same period of time as a means of attempting to commercialise their technology, or simply less technology to commercialise as a result of having lower quality research, as illustrated in the fact that neither are part of the Russell Group, unlike UoB.

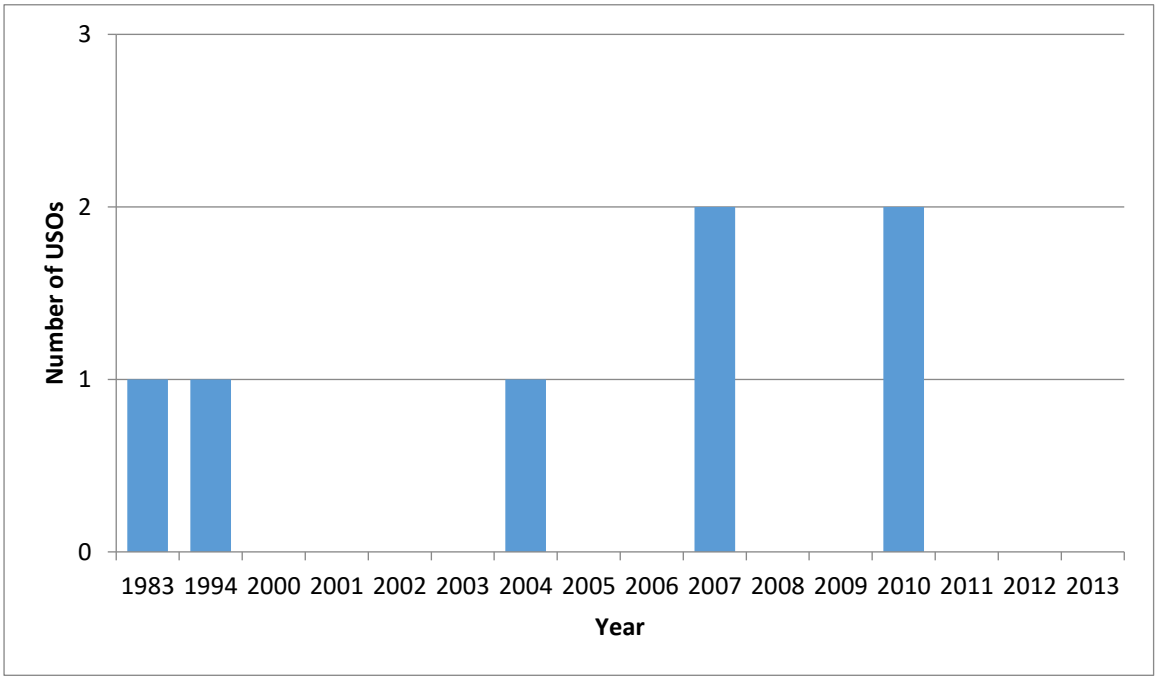


Figure 6.1: Aston USOs, total population, number by year

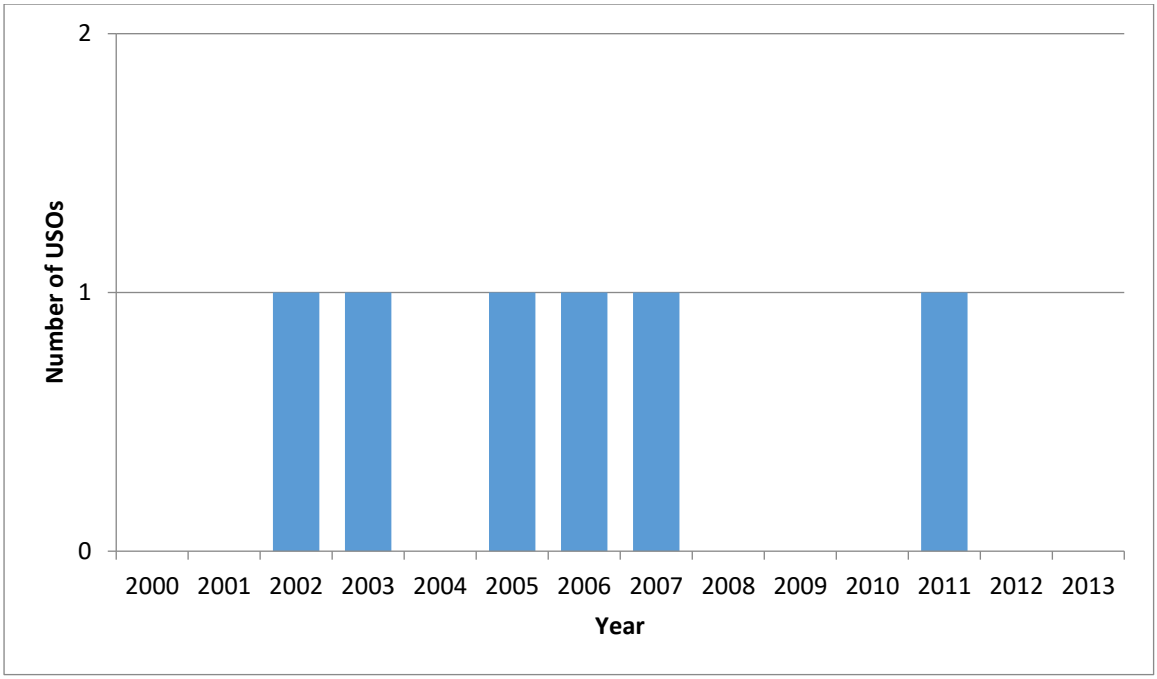


Figure 6.2: Keele USOs, total population, number by year

In arriving at the final population of USOs for Aston, as with the UoB, it became clear that none of the three sources would have been sufficient by themselves to give an adequate reflection of the true USO population. In particular, unlike UoB, Spinouts UK proved inaccurate in identifying a number of USOs which further investigation proved not to be, implying that the database received inaccurate information from its sources. This again highlights the need, in order to obtain an accurate dataset, not to rely on one source and to check it thoroughly against published financial data. In the case of Keele, however, USOs were consistent across the three data sources, with only one potential USO being discarded from the original sample.

6.2.2 Results

The tables below (Tables 6.5 and 6.6) shows basic classification data for the USOs obtained from the sources noted above, and summarized in Figures 6.3 and 6.4.

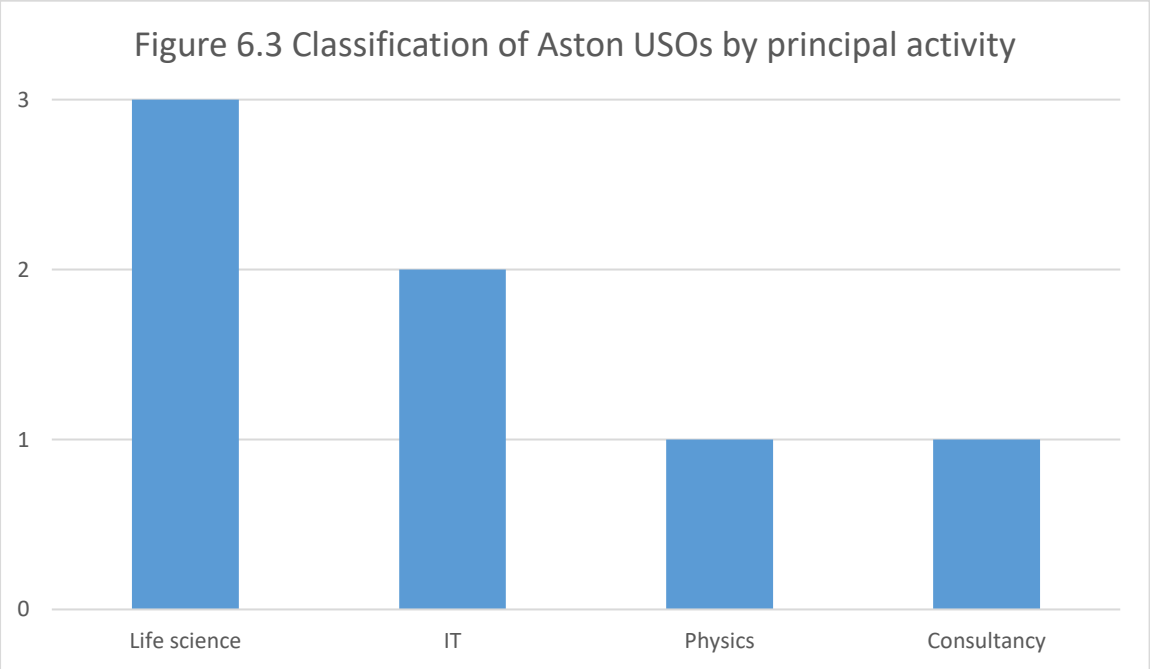
USO name	Company registration number	Principal activity	Classification
Aerbuddies Limited	6439351	Develop treatment for ear pain	Life science
Astelics Limited	6113352	Develop components for telecoms	IT
Aston Business Assessments Limited	7200897	Business Psychology Training	Consultancy
Aston Molecules Limited	1709877	Pharmaceutical development	Life science
Aston Photonic Technologies	4139246	Photonic technology	Physics

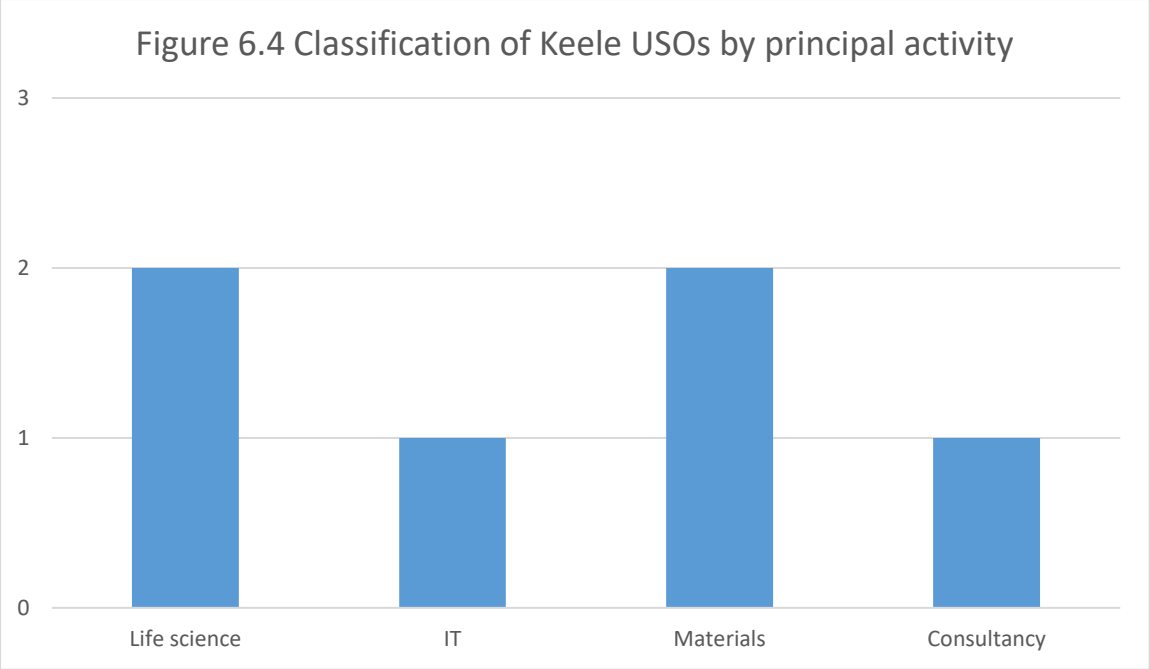
Limited			
Protamax Limited	5200397	Biotechnology services	Life science
Sapere Systems Limited	7171338	Develop computer assisted devices	IT

Table 6.5 Basic classification of Aston USOs

USO name	**Company registration number**	**Principal activity**	**Classification**
Intelligent Orthopaedics Limited	4504094	Develop orthopaedic trauma devices	Life science
SciCorr Limited	7862592	Identifying corroded steel	Materials
Prescribing Decision Support Limited	5789221	Software to assist pharmacist decisions	IT
nanoTherics Limited	6332067	Magnetic nanoparticle research	Materials
MagneCell Limited	4696405	Tissue engineering	Life science
SciSite Limited	5398570	Ferrous corrosion consultancy services	Consultancy

Table 6.6 Basic classification of Keele USOs





As for UoB, USOs seeking to commercialise technologies within the fields of life sciences and IT (information technology) comprise the majority of those originating from both Aston and Keele, a feature commonly observed in studies at other universities e.g. Oskarsson and Schläpfer (2008). It should be noted that the classifications used are broad and, especially in the cases of USOs dissolved many years prior to the data collection, it was not always easy to find out the exact nature of their activities. This was a common issue for all the data considered in this chapter.

6.2.3 Survival measurements

Dates of incorporation and dissolution (where relevant) were obtained for each of the USOs from Experian Corpfin and are tabulated below.

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Aerbuddies Limited	28/11/07			
Astelics Limited	19/2/07	5/7/11	52	Y
Aston Business Assessments Limited	24/3/10			
Aston Molecules Limited	25/3/83	28/11/13	368	Y
Aston Photonic Technologies Limited	14/6/94	14/1/14	235	Y
Protamax Limited	9/8/04	28/7/11	83	Y
Sapere Systems Limited	26/2/10			

Table 6.7 Survival data for Aston USOs

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Intelligent Orthopaedics Limited	6/8/02			
SciCorr Limited	28/11/11			
Prescribing Decision Support Limited	21/4/06			
nanoTherics Limited	2/8/07			
MagneCell Limited	13/3/03	27/10/09	79	N
SciSite Limited	18/3/05	28/6/13	99	Y

Table 6.8 Survival data for Keele USOs

As noted above, 7 Aston USOs in total were identified with dates of incorporation ranging from 1983 to 2010. Of the 7 USOs identified, 4 had been formally dissolved. This represents an aggregate failure rate of 57%, although two of the USOs survived for 20 years or more, which is a significant lifespan for a company. For Keele, 6 USOs in total were identified with dates of incorporation ranging from 2002 to 2011. Of the 6 USOs identified, 2 had been formally dissolved. This represents an aggregate failure rate of 33%. The average time to failure of the 4 dissolved companies from Aston was 185 months and ranged from 52 months to 368 months, while that of the two dissolved companies from Keele was 89 months and ranged from 79 to 99 months

As with UoB, a number of 'twilight USOs' were identified during the data collection. While an element of judgment has to be made as to whether a company has ceased to trade, a further 2 companies from Aston (29% of the sample) and 2 companies from Keele (33% of the sample) were identified as twilight USOs. The population's total effective aggregate failure rate is thus 86% (6 out of 7 USOs) and 66% (4 out of 6 USOs) respectively. Tables 6.6 and 6.7 below reveals the identity of the twilight USOs, as well as the rationale behind their designation as such.

USO	Rationale for 'twilight' designation
Aerbuddies Limited	Company effectively dormant – very little activity
Aston Business Assessments Limited	No funding since incorporation – very little activity as a consulting company

Table 6.9: Rationale for Aston 'twilight' designation

USO	Rationale for 'twilight' designation
Intelligent Orthopaedics Limited	Last funding in 2010 but credit report shows adverse information (company subsequently dissolved)
Prescribing Decision Support Limited	No funding since incorporation – very little activity as a consulting company

Table 6.10: Rationale for Keele 'twilight' designation

As with UoB, comparison of Aston and Keele's USO survival rates with existing academic studies of USO financial performance reveals a number of interesting findings. In general, it is clear that this study shows a lower rate of survival amongst USOs than most other studies (as summarized in Oskarsson and Schläpfer, 2008) when considering only formally dissolved USOs (43% for Aston, 66% for Keele), and a significantly lower rate than all other studies identified in the previous chapter if 'twilight USOs' are included (14% for Aston, 33% for Keele), which again implies that 'twilight USOs' are an important class of USO that may shed some light upon the apparent longevity of USOs compared to other start-up companies as noted in the academic literature to date e.g. de Cleyn (2011). As with UoB, this initial finding shows some consistency with signaling theory as these Plate Glass universities are less research-intensive than the single universities studied to date (Oskarsson and Schläpfer, 2008) and hence less prestigious, sending out weaker signals to potential investors. However, such conclusions must be made with care, and as already noted, other studies have shown little correlation between research strength of a university and the number of USOs generated (Shane, 2004); this may imply a similar lack of correlation with USO survival.

6.2.4 Third party investment results

Tables 6.11 and 6.12 below show which of the Aston and Keele USOs obtained external third party funding and the amount of such funding received by each company. The data on funding was obtained primarily from analysis of USO statutory accounts, particularly from review of the share premium account movements, which represent the excess amount of the total investment by a third party over the nominal value of the share capital acquired.

USO	Investment received	Amount (£)
Aerbuddies Limited	Y	8,000
Astelics Limited	Y	13,500
Aston Business Assessments Limited	N	
Aston Molecules Limited	Y	161,920
Aston Photonic Technologies Limited	Y	4,270,938
Protamax Limited	Y	14,600
Sapere Systems Limited	Y	12,470

Table 6.11: Third party investment attracted by Aston USOs

USO	Investment received	Amount (£)
Intelligent Orthopaedics Limited	Y	1,332,232
SciCorr Limited	Y	158,800
Prescribing Decision Support Limited	N	
nanoTherics Limited	Y	1,907,367
MagneCell Limited	N	
SciSite Limited	Y	99,920

Table 6.12: Third party investment attracted by Keele USOs

6 out of 7 Aston USOs received external third party investment which represents 86% of the total population, and 4 out of 6 for Keele (66% of the population). A total of £4,481,428 of investment was received from third parties for Aston USOs and £3,418,319 for Keele. Tables 6.13 and 6.14 provide more detail on the identities of the investors.

USO	UCF (Mercia Fund)	Other private equity	Individuals	Other	Detail
Aerbuddies Limited			Y		
Astelics Limited		Y			H20 Venture Partners
Aston Molecules Limited				Y	Birmingham City Council via Birmingham Technology (Venture Capital) Limited
Aston Photonic Technologies Limited		Y	Y		3i (£4m) and individuals
Protamax Limited			Y		
Sapere Systems Limited		Y			H20 Venture Partners

Table 6.13 Identities of external investors in Aston USOs

USO	UCF (Mercia Fund)	Other private equity	Individuals	Detail
Intelligent Orthopaedics Limited	Y	Y		Other private equity was Catapult Venture Managers
SciCorr Limited			Y	
nanoTherics Limited	Y	Y		Other private equity was Catapult Venture Managers
SciSite Limited		Y		Advantage Early Growth Fund

Table 6.14 Identities of external investors in Keele USOs

These findings are slightly different from what would be expected from agency and signaling theory when compared to UoB. Plate Glass universities are generally considered to be slightly less prestigious from a research perspective than Russell Group universities, yet Aston and Keele show higher rates of attracting finance, as well as a wide range of investors. Clearly the relationship between research prestige of a university and attracting finance for its USOs is not a simple one, and a wider comparison across the region and with other UK universities will need to be performed to shed more light. This may hint that the policy of the university in creating USOs is of importance, with lower numbers of higher quality USOs being of more significance in sending out positive signals to, or building trust with, potential investors than simply the research prestige of the sponsoring university. However, care should be taken in drawing conclusions, as it should be noted that Aston and Keele have very small numbers of USOs so results can easily be distorted, and Aston in particular may still have strong roots in science and technology from its initial formation as a College of Advanced Technology.

Given the high number of investors and funding rounds in some cases, it was not always possible to identify the amount invested by each investor as such data was not publicly available. The Mercia Fund, which was the University Challenge Fund set up by the UK government to provide early stage funding to USOs (see earlier chapter for more details), unlike UoB did not invest of any of Aston's USOs. The Fund underwent a management buy-out some years after its formation and launched additional investment funds; these have all been grouped together under the 'Mercia Fund' designation for this study.

6.2.5 USOs achieving an exit

As already noted, an important goal of a USO created to commercialise university technology is to achieve a financial return for the university by an exit from the company, via a public listing of shares or other form of share disposal such as a trade sale. Of the 7 Aston USOs, 2 led to a successful exit for shareholders via a trade sale of the entire share capital to a third party. None of the USOs offered any shares to the public via a stock market listing. However, this is a much higher proportion of successful exits than the UoB. None of the 6 Keele USOs exited successfully which may be a result of its lower scientific heritage and less research-intensive focus.

A more detailed historical analysis of the two USOs was undertaken through review of their financial accounts and other publicly available information to provide more details about the nature of the trade sale and whether the terms of the sale were beneficial to Aston.

6.2.5.1 Aston Molecules Limited

This USO was founded in 1983 with the aim of commercialising Aston technology in the field of providing discovery and pharmaceutical development services to the worldwide pharmaceutical industry. Aston held a very small stake of 10 shares with a number of university academics holding 1650 shares between them. External funding was provided to the tune of £161,920 by Birmingham City Council via its wholly owned entity Birmingham Technology (Venture Capital) Limited.

In 1996 the entire share capital of the company was sold to Oncogene Science Inc., an American group listed on the NASDAQ Stock Exchange. The total consideration was $3million which consisted of shares in the acquiring company. Aston received its share of the consideration i.e. £7,831. At the date of sale the USO had net assets of £139,462 and a deficit on its profit and loss reserve of

£24,118, so the technology in the USO was still in development phase, although was clearly worth significantly more than the overall net asset position of the company given the price paid.

It is notable that the date of formation of this USO is very early, and even before the 1985 UK government reform designed to open up universities to allow their technologies to be commercialised. The company was very successful in that its technology had significant financial value which was recognised by an external purchaser. However, it should be noted that Aston received hardly any of the sale proceeds, a situation which was remedied in later USOs with a larger university equity stake being taken. The main beneficiary from the sale was the local City Council, an unusual investor and certainly not one seen in later USOs. Interestingly, the profits on sale were therefore probably genuinely ploughed back into the local community, a very rare example of a 'people's USO'.

From a theoretical perspective, signaling theory would suggest that this USO gave off very strong positive signals to investors about the strength of its technology both to the initial early investors and the subsequent purchaser, possibly through patents or other protection obtained, or the quality of the management team and their experience in the technology field. Agency theory would suggest little goal incongruence between the original shareholders as all parties wished to achieve a subsequent sale of the company. In this example, the two frameworks complement each other and observation of the lifestyle of the USO is consistent with the predictions of both.

6.2.5.2 Aston Photonic Technologies Limited

This USO was founded in 1994 as Indigo Photonics Limited to commercialise photonic technology developed at Aston. Funding of £4 million was received from UK-listed private equity group 3i in 2001. Aston transferred IP to the company in exchange for 63,750 ordinary £1 shares. Academics and individuals also contributed £270,938 of investment.

In 2003 the entire share capital of the company was acquired by Insensys Limited for £482,941 via a share for share exchange. Aston received £52,210 in return for its stake. At the date of acquisition, the company had negative net assets of £70,891 and a profit and loss deficit of £995,924, showing that the company was still in the development phase with respect of its technology. Again, this is a very early USO, formed well before the phenomenon increased in popularity in the UK, and was again successful in attracting investment, although did not make financial returns for its investors.

6.2.5.3 Summary – Plate Glass universities

The Plate Glass universities of Aston and Keele reveal a number of features of interest which will be compared against other universities from different categorisations within the region in Chapter 7. The major differences from the Russell Group UoB that will be worthy of further discussion are the much smaller number of USOs generated, the similar observations over twilight USOs and the high failure rate compared to previous studies (in line with the predictions of signalling theory) and the successful exit from a financial perspective of one of the Aston USOs. Both universities, however, show a high rate of obtaining funding compared to the UoB, which is against the predictions of signalling theory from consideration of the research strength of the parent university, and suggests that other factors are important in the decision-making of the receiver of the signals.

6.3 Post-92 Universities - Coventry University and Staffordshire University

Coventry University (Coventry) received its university status in 1992 along with a number of former polytechnics. It was originally formed as the Lanchester College of Technology in 1961 to cater for the high level of technical training required in Coventry. The institution merged with Rugby College of Engineering Technology to form Lanchester Polytechnic in 1970, which was renamed Coventry Polytechnic in 1987. Like Aston, it has a history of offering technology-based study courses, and it currently hosts about 27,000 students. It has a wholly-owned subsidiary company that deals with commercialisation and technology transfer called Coventry University Enterprises Limited (CUE), which holds equity stakes in Coventry USOs for the university. The city of Coventry has historically been the site of much automotive manufacture and supporting industries, and the university has a strong reputation for its engineering courses, that specialise in this sector.

Staffordshire University (Staffs) obtained university status in 1992 as one of a cohort of former polytechnics along with Coventry, although it was originally founded as far back as 1914 as the Central School of Science and Technology to support the two main industries of Stoke-on-Trent, namely pottery and mining, which was later transformed into Staffordshire Polytechnic. It currently hosts about 19,000 students.

6.3.1 Constructing and refining the USO database

Four independent, third party data sources were identified and used to create the USO database, in line with the methodology discussed in the previous chapter, during April 2014:

i) Coventry and CUE's annual accounts obtained from the University website covering the years ended 31 July 2005 to 31 July 2013 inclusive, and Staffs from 31 July 2004 to 31 July 2014 inclusive.

ii) Company searches were performed using the Experian Corpfin UK business database which provides data from all UK company accounts filed at Companies' House, to identify companies in which CUE or Staffs were a current shareholder.

iii) A search of the Spinouts UK database was performed to find all USOs identified as associated with Coventry and Staffs by this specific database.

iv) CUE and Staffs's websites provided some detail of companies which they identified as being USOs.

Each of these four sources gave rise to a different population of companies that were potentially USOs. These were cross-checked and amalgamated to form a single set, which is shown below in Tables 6.15-16. The data was then refined through in-depth analysis of each potential USO's historic financial data, primarily in the form of company accounts and annual returns, in order to reject companies that did not meet the chosen definition of a USO.

Company	University accounts	Experian	CUE website	Spinouts UK	USO?
Exilica Limited	Y	Y	Y	Y	Y
Advanced Construction Technologies (UK) Limited		Y			N
Inocardia Limited		Y			Y
Health Behaviour Research Limited	Y	Y	Y		Y
Microcab Industries Limited	Y	Y	Y		Y
Tortrix Limited		Y	Y		Y
The Futurelets Limited		Y			N
Sprue Aegis Limited			Y		N
Future Armour Limited			Y	Y	Y
MCC Engines Limited	Y				Y
Membrasense Limited	Y				Y
Cavisys Limited	Y			Y	Y
Trucktrain Knowhow Limited	Y				N
Natural8 Limited	Y				N
UK Unplugged Technology Limited	Y				N
WEEE Suitcase Limited	Y			Y	Y
Virtualis3D Limited	Y			Y	Y
Intelligent Paving Systems Limited	Y				N
GPS Vision Limited				Y	N

Table 6.15 Potential Coventry USOs identified from the data sources

Company	Experian	University accounts	TTO website	Spinouts UK	USO?
Ava Technologies Limited	Y	Y	Y	Y	Y
Flux Stoke on Trent Limited	Y	Y	Y	Y	Y
Grand Independent Limited		Y	Y	Y	N
Intelligent Orthopaedics Limited (also a USO of Keele – see above)	Y	Y	Y	Y	Y
Picture Nation Limited	Y	Y			Y
Ludorum Studios Limited	Y	Y			N
iCentrica Limited	Y	Y			Y
Linkway Software Limited		Y			N

Blackstone Resourcing Limited	Y	Y			Y

Table 6.16 Potential Staffs USOs identified from the data sources

Companies identified as potential USOs by one of the sources, but which were rejected from the final data set upon further analysis, are shown in the following table (Tables 6.17-8) together with the reasons for rejection.

Company name	**Reason for rejection as USO**
Advanced Construction Technologies (UK) Limited	Appears to be a training consortium; CUE owns 1 out of the company's 715,001 shares
The Futurelets Limited	100% owned by CUE and appears to be accommodation-related (formed in 2014)
Sprue Aegis Limited	CUE only ever held a 2% stake, probably as a result of a past collaboration (company is now AIM-listed)
Trucktrain Knowhow Limited	Dormant since incorporation
Natural8 Limited	Wholly-owned subsidiary now dissolved
UK Unplugged Technology Limited	Dormant since incorporation and now dissolved
Intelligent Paving Systems Limited	CUE owns no shares (university accounts incorrect)
GPS Vision Limited	Consultancy business set up by Coventry academic; CUE owns no shares

Table 6.17 Rationale for rejection of companies as Coventry USOs

Company name	**Reason for rejection as USO**
Grand Independent Limited	No shares owned by the University – likely to be a startup
Ludorum Studios Limited	Dormant since incorporation
Linkway Software Limited	No shares owned by the University

Table 6.18 Rationale for rejection of companies as Staffs USOs

Refining the data gave a final total population for Coventry of 11 USOs incorporated between 1989 and 2013, and 6 for Staffs between 2002 and 2012. 2005 was the most popular year for Coventry with 3 USOs being incorporated (Figure 6.5) while Staffs formed no more than one per year. No USOs were formed at all before 2002 for either university highlighting the fact that the phenomenon of significantly increasing numbers is a relatively new one. Unlike the UoB and Aston, USOs continued to be formed after 2010, which could imply that this route remains viable for both as a means of commercialising university technology. Unlike UoB, however, there is no discernible pattern in terms of increasing or decreasing numbers of USOs, and numbers overall are much lower, with few examples of more than one USO being formed in a year. This may suggest that Coventry and Staffs may have had less capacity for setting up USOs over the same period of time to

commercialise technology, or simply had less technology that was ready to commercialise, which would be expected from their much lower research strength.

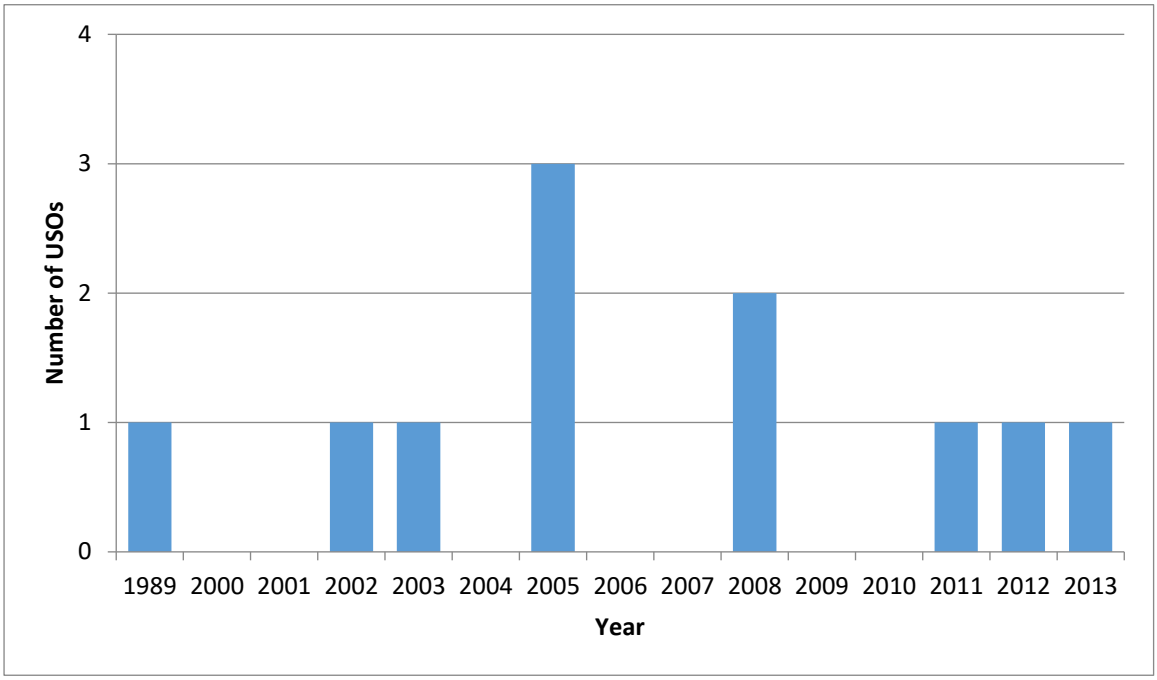


Figure 6.5: Coventry USOs, total population, number by year

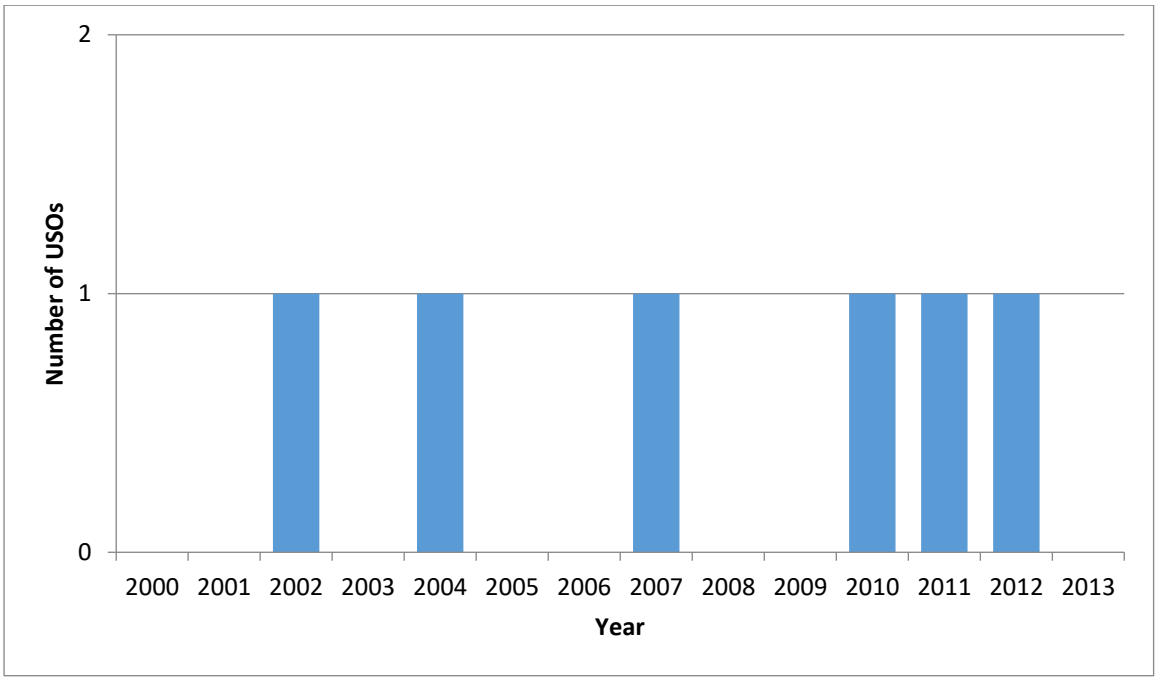


Figure 6.6: SU USOs, total population, number by year

In arriving at the final population of USOs, as with the UoB and Aston, it became clear that none of the four sources would have been sufficient by themselves to give an adequate reflection of the true USO population. In particular, unlike UoB, Spinouts UK proved inaccurate in failing to identify a number of older USOs, implying that the database received inaccurate information from its sources which may have focused on newer USOs only. This again highlights the need, in order to obtain an accurate dataset, not to rely on one source and to check it thoroughly against published financial data.

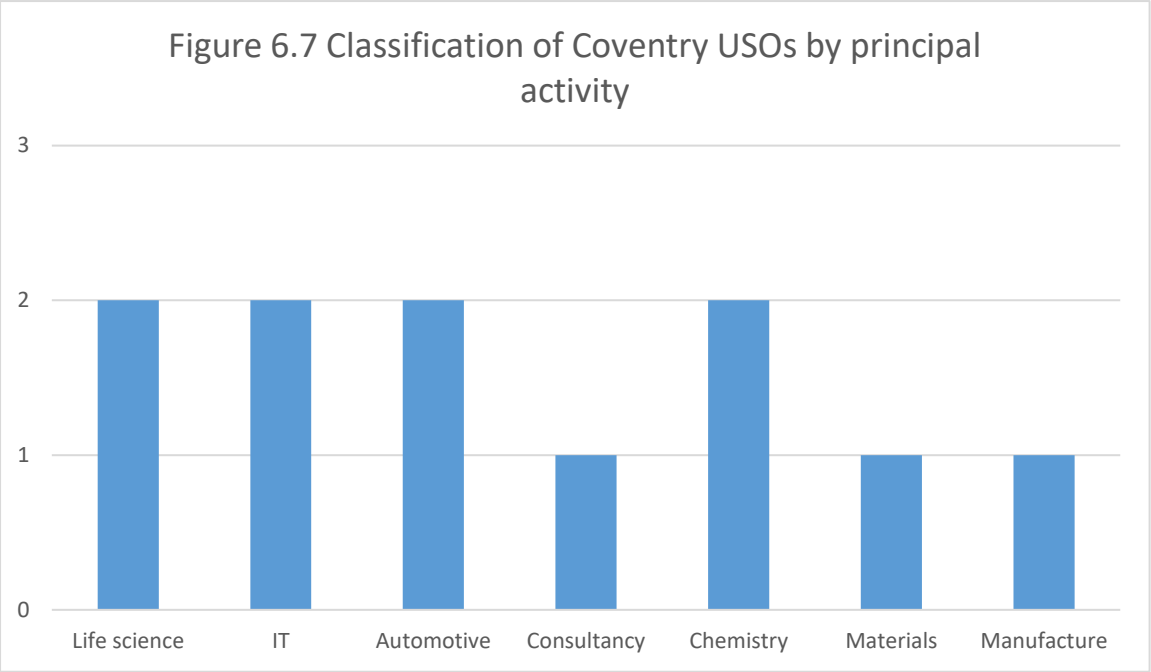
6.3.2 Results

USO name	Company registration number	Principal activity	Classification
Exilica Limited	5467661	Develop nanoscale polymer particles	Materials/polymers
Inocardia Limited	8573417	Develop assays for biotech and pharma sectors	Life science
Health Behaviour Research Limited	5467654	Consultancy	Consultancy
Microcab Industries Limited	4607731	Automotive manufacture	Automotive
Tortrix Limited	6564337	Software development	IT
Future Armour Limited	8257058	Manufacture workwear	Manufacture
MCC Engines Limited	2387591	Develop auto engine	Automotive
Membrasense Limited	4705038	Develop artificial membranes	Life science
Cavisys Limited	5359431	Develop water purification techniques	Chemistry
WEEE Suitcase Limited	6477693	Refuse disposal	Chemistry
Virtualis3D Limited	7523551	Entertainment	IT

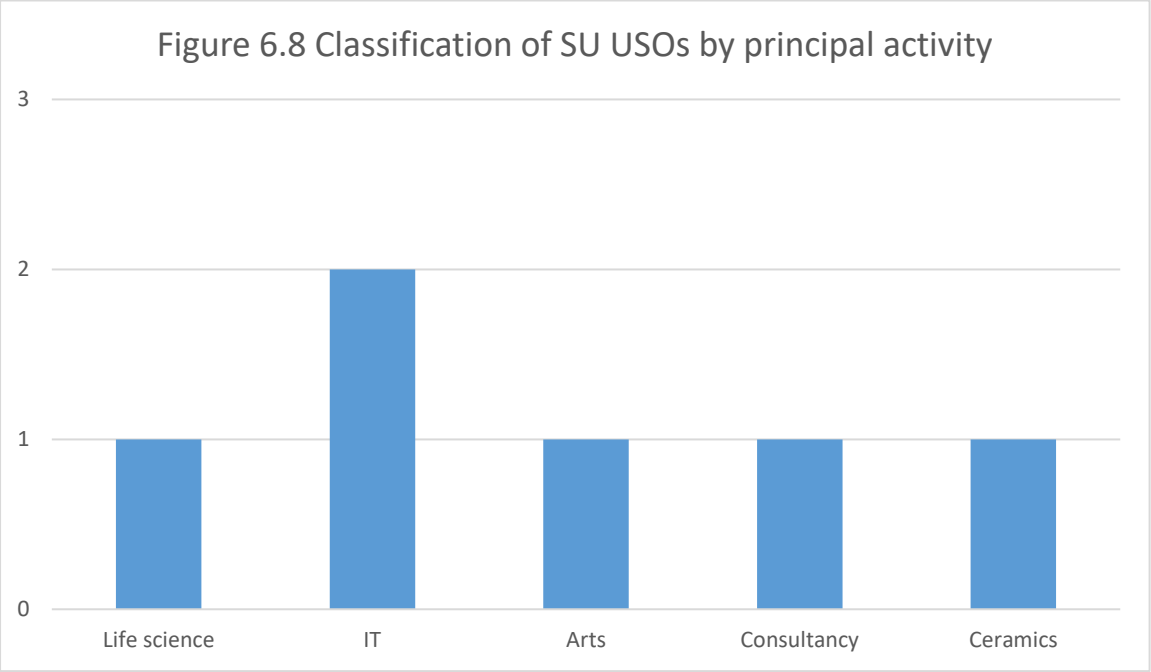
Table 6.19 Basic classification of Coventry USOs

USO name	Company registration number	Principal activity	Classification
Ava Technologies Limited	7451691	Video analytics	IT
Flux Stoke on Trent Limited	7742399	Tableware production	Ceramics
Intelligent Orthopaedics Limited	1709877	Develop orthopaedic trauma devices	Life science
Picture Nation Limited	5308570	Maintain photo images bank	Arts
iCentrica Limited	8311757	Software development	IT
Blackstone Resourcing Limited	6147341	Recruitment agency	Consultancy

Table 6.20 Basic classification of Staffs USOs



Unlike UoB and Aston, Coventry shows a much wider spread of activities for its USOs, and Staffs's are more focused on the arts and digital rather than science and technology, reflecting its recent creation as a university. Given the city of Coventry's automotive heritage, it is maybe not surprising to see automotive-based USOs amongst the population.



6.3.3 Survival measurements

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Exilica Limited	31/5/05			
Inocardia Limited	18/6/13			
Health Behaviour Research Limited	31/5/05			
Microcab Industries Limited	4/12/02			
Tortrix Limited	14/4/08			
Future Armour Limited	17/10/12			
MCC Engines Limited	22/5/89	17/3/06	201	Y
Membrasense Limited	20/3/03	13/7/07	51	N
Cavisys Limited	9/2/05	7/7/09	52	N
WEEE Suitcase Limited	18/1/08	30/10/12	57	N
Virtualis3D Limited	9/2/11	29/9/13	31	N

Table 6.21 Survival data for Coventry USOs

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Ava Technologies Limited	25/11/10			
Flux Stoke on Trent Limited	16/8/11			
Intelligent Orthopaedics Limited	6/8/02			
Picture Nation Limited	9/12/04	20/5/14	114	N
iCentrica Limited	29/11/12			
Blackstone Resourcing Limited	8/3/07	14/12/10	45	N

Table 6.22 Survival data for Staffs USOs

Of the 11 Coventry USOs identified, 5 had been formally dissolved, as had 2 of the 6 Staffs USOs. This represents an aggregate failure rate of 45% for Coventry, although one of the USOs survived for over 15 years, which is a significant lifespan for a company, and 33% for Staffs.

As with UoB, a number of 'twilight USOs' were identified during the data collection. While an element of judgment has to be made as to whether a company has ceased to trade, a further 2 Coventry companies (18% of the sample) and 3 Staffs USOs (50% of the sample) were identified as twilight USOs. The populations' total effective aggregate failure rate is thus 64% (7 out of 11 USOs)

and 83% (5 out of 6 USOs) respectively. Tables 6.23-24 below reveals the identity of the twilight USOs, as well as the rationale behind their designation as such.

USO	Rationale for 'twilight' designation
Health Behaviour Research Limited	No funding since incorporation – very little activity as a consulting company
Tortrix Limited	No funding since incorporation – very little activity as a consulting company

Table 6.23: Rationale for Coventry 'twilight' designation

USO	Rationale for 'twilight' designation
Ava Technologies Limited	Company effectively dormant – very little activity
Intelligent Orthopaedics Limited	Last funding in 2010 but credit report shows adverse information (company subsequently dissolved)
iCentrica Limited	Company effectively dormant – very little activity

Table 6.24: Rationale for Staffs 'twilight' designation

As with UoB and Aston, comparison of Coventry and Staffs's USO survival rates with existing academic studies of USO financial performance reveals a number of interesting findings. In general, it is clear that this study shows a lower rate of survival amongst USOs than most other studies when considering only formally dissolved USOs (55% for Coventry, 67% for Staffs), and a significantly lower rate than all other studies identified in the previous chapter if 'twilight USOs' are included (36% for Coventry, 16% for Staffs), which again implies that 'twilight USOs' are an important class of USO that may shed some light upon the apparent longevity of USOs compared to other start-up companies as noted in the academic literature to date e.g. de Cleyn (2011). The survival rates are low compared to prior studies (Oskarsson and Schläpfer, 2008) which is consistent with signalling as these Post-92 universities are less research-intensive and hence their USOs are less attractive to funders.

6.3.4 Third party investment results

Tables 6.25-26 below shows which of the Coventry and Staffs USOs obtained external third party funding and the amount of such funding received by each company. The data on funding was obtained primarily from analysis of USO accounts, particularly from review of the share premium account movements, which represent the excess amount of the total investment by an investor over the nominal value of the share capital acquired.

USO	Investment received	Amount (£)
Exilica Limited	Y	549,008
Inocardia Limited	Y	229,948
Health Behaviour Research Limited	N	
Microcab Industries Limited	Y	85,000 (CUE invested 150k)
Tortrix Limited	N	
Future Armour Limited	N	
MCC Engines Limited	Y	267,809
Membrasense Limited	N	
Cavisys Limited	N	
WEEE Suitcase Limited	N	
Virtualis3D Limited	N	

Table 6.25: Third party investment attracted by Coventry USOs

USO	Investment received	Amount (£)
Intelligent Orthopaedics Limited	Y	1,332,232
Ava Technologies Limited	N	
Flux Stoke on Trent Limited	N	
Picture Nation Limited	N	
iCentrica Limited	N	
Blackstone Resourcing Limited	N	

Table 6.26: Third party investment attracted by Staffs USOs

4 out of 11 Coventry USOs received external third party investment which represents 36% of the total population, and 1 out of 6 for Staffs (16% of the total population). A total of £1,131,765 of investment was received from third parties which aimed to commercialise Coventry intellectual property and £1,332,232 for Staffs. Table 6.16 provides more detail on the identities of the investors.

USO	UCF (Mercia Fund)	Other private equity	Companies	Individuals	Detail
MCC Engines Limited				Y	
Exilica Limited			Y		Watts Blake Bearne Limited (part of a large multinational group)
Inocardia Limited		Y			Mercia Fund (new form)
Microcab Industries Limited				Y	

Table 6.27 Identities of external investors in Coventry USOs

USO	University Challenge Fund (Mercia Fund)	Other private equity	Detail
Intelligent Orthopaedics Limited	Y	Y	Other private equity was Catapult Venture Managers

Table 6.28 Identities of external investors in SU USOs

These findings are in line with predictions of signalling theory in that less funding is received than for UoB, Aston and Keele, which are more research-intensive and send stronger signals about the quality of their technologies. From agency theory's perspective, the small number of USOs involved makes it difficult to compare the range of investors, who would be attracted once a university TTO becomes established in creating USOs that attracted funding. Given Coventry's heritage for research and development in the automotive sector, this may suggest that the university and manufacturers have used other, more effective means than USO creation to effect technology transfer from academia.

6.3.5 USOs achieving an exit

None of the USOs from Coventry or Staffs achieved an exit that yielded any financial benefit for shareholders, which is in line with signalling theory which predicts that USOs from low research-intensive universities that do not focus on science or technology would be relatively unattractive to potential purchasers or investors via an IPO.

6.3.6 Summary

The Post-92 universities in the region that have created USOs, namely Coventry and Staffs, have shown some properties worthy of further discussion. USO numbers are much lower than the Russell Group UoB which could reflect the disparity in quality of scientific research. USO survival rates are low although the fact that population sizes are low will hinder drawing definitive conclusions, and twilight USOs are again present. The lower levels of funding obtained and lack of any exit compared to the rest of the region are in line with signalling theory given the Post-92 universities' relative research weaknesses and hence lack of attractive technologies for investors to support.

6.4 University of Warwick

The University of Warwick (UoW) received its Royal Charter in 1965. Although a relatively modern university, it is a member of the Russell Group and consistently ranks very highly alongside the elite UK universities in various ranking studies. It currently hosts about 23,000 students and has a reputation for its commercial focus, as well as its research strengths in science and technology. It conducts research across the whole range of basic and applied sciences, including life sciences and biomedical sciences, as well as IT and engineering.

6.4.1 Constructing and refining the USO database

Four independent, third party data sources were identified and used to create the USO database, in line with the methodology discussed in the previous chapter. Data was collected during April and May 2014:

i) UoW's annual accounts obtained from the University website covering the years ended 31 July 2000 to 31 July 2013 inclusive.

ii) Company searches were performed using the Experian Corpfin UK business database which provides data from all UK company accounts filed at Companies' House, to identify companies in which UoW was a current shareholder. A range of search terms derived from the descriptor "University of Warwick" was used to capture USOs as variations were present in recording the identity of the University as a shareholder in the company's Annual Returns.

iii) A search of the Spinouts UK database was performed to find all USOs identified as associated with UoW by this specific database.

iv) Details of USOs were provided in the technology transfer section of the UoW website

Each of these four sources gave rise to a different population of companies that were potentially USOs. These were cross-checked and amalgamated to form a single set, which is shown below in Table 6.33. The data was then refined through in-depth analysis of each potential USO's historic financial data, primarily in the form of company accounts and annual returns, in order to reject companies that did not meet the chosen definition of a USO.

Company	Experian	University accounts	TTO website	Spinouts UK	USO?
Allinea Software Limited	Y	Y	Y	Y	Y
Anvil Semiconductors Limited	Y	Y	Y	Y	Y
Apnee Sehat CIC	Y	Y	Y		N
A2SP Limited		Y		Y	Y
Base4 Innovation Limited	Y	Y	Y	Y	Y
BioAthene Limited		Y			Y
Biotek Limited	Y	Y			Y
Cambridge CMOS Sensors Limited	Y	Y	Y		N
Cellfacts Instruments Limited				Y	N
Circadian Solar Limited	Y	Y		Y	Y
Clinvivo Limited	Y			Y	Y
Concurrent Thinking Limited	Y	Y	Y	Y	Y
Decision Technology Limited		Y	Y	Y	N

Digeprint Limited		Y		Y	Y
Gadametric Limited		Y		Y	Y
goHDR Limited	Y	Y	Y	Y	Y
G-Tronix Limited		Y		Y	Y
Herfurth Laser Technology Limited		Y			Y
Incentec Limited		Y		Y	Y
Insight Solutions Limited		Y			N
Microbial Systems Limited				Y	Y
Molecular Solar Limited		Y		Y	Y
Multimetaphase Limited		Y			Y
Neurosolutions Limited (parent Sevco 5023)		Y	Y	Y	Y
Novolytics Limited		Y	Y	Y	Y
Opscape Limited		Y		Y	Y
Optical Antenna Solutions Limited		Y		Y	Y
Prospero Therapeutics Limited		Y		Y	Y
Recycling Technologies Limited	Y		Y	Y	Y
Sarissa Biomedical Limited		Y	Y	Y	Y
Septegen Limited		Y		Y	Y
Shibden Technologies Limited		Y		Y	Y
Sonemat Limited	Y	Y	Y	Y	Y
Sorption Energy Limited	Y	Y	Y	Y	Y
Stella Biomedica Limited				Y	N
Streamline Computing Limited		Y		Y	Y
Tangent Reprofiling Limited	Y	Y	Y	Y	Y
Therapro Systems Limited		Y			Y
Virabiotech Limited		Y		Y	Y
Virionhealth Limited	Y			Y	N
Vizeye Limited	Y	Y	Y	Y	Y
Warwick Analytical Software Limited	Y			Y	Y
Warwick Audio Technologies Limited		Y	Y	Y	Y
Warwick Control Technologies Limited		Y		Y	N
Warwick Dynamics Limited		Y			N
Warwick Effect Polymers Limited		Y	Y	Y	Y

Warwick Insect Technologies Limited	Y	Y		Y	Y
Warwick Laser Systems Limited	Y	Y		Y	Y
Warwick Moulding Technology Limited		Y		Y	Y
Warwick Plant Genomic Libraries Limited		Y		Y	Y
Warwick Sensor Technologies Limited		Y			Y
Warwick Warp Limited	Y	Y	Y	Y	Y

Table 6.29 Potential UoW USOs identified from the data sources

Companies identified as potential USOs by one of the sources, but which were rejected from the final data set upon further analysis, are shown in the following table (Table 6.29) together with the reasons for rejection.

Company name	**Reason for rejection as USO**
Apnee Sehat CIC	Community investment company – social enterprise
Cambridge CMOS Sensors Limited	USO from Cambridge University that licensed UoW technology
Cellfacts Instrments Limited	UoW holds no shares – company bought trade and assets of UoW USO Microbial Systems Limited
Decision Technology Limited	Staff startup – UoW held no shares
Insight Solutions Limited	UoW held no shares
Stella Biomedica Limited	Company never filed accounts
Virionhealth Limited	UoW held no shares
Warwick Control Technologies Limited	UoW held no shares
Warwick Dynamics Limited	Company dormant since incorporation

Table 6.30 Rationale for rejection of companies as UoW USOs

Refining the data gave a final total population for UoW of 43 USOs incorporated between 1988 and 2012. 2002, 2004 and 2005 were the most popular years with 5 USOs being incorporated (Figure6.9). No USOs were formed at all between 1988 and 1999 highlighting the fact that the phenomenon of significant increases in the USO population is a relatively new one. In addition, as with the UoB, the number of USOs formed after 2010 dropped noticeably, which may imply that this route is losing attractiveness as a means of commercialising university technology. Unlike UoB, however, the numbers of USOs formed has not stopped, and numbers overall are much higher, suggesting that UoW may have had more enthusiasm for setting up USOs over the same period of time as a means of attempting to commercialise its technology.

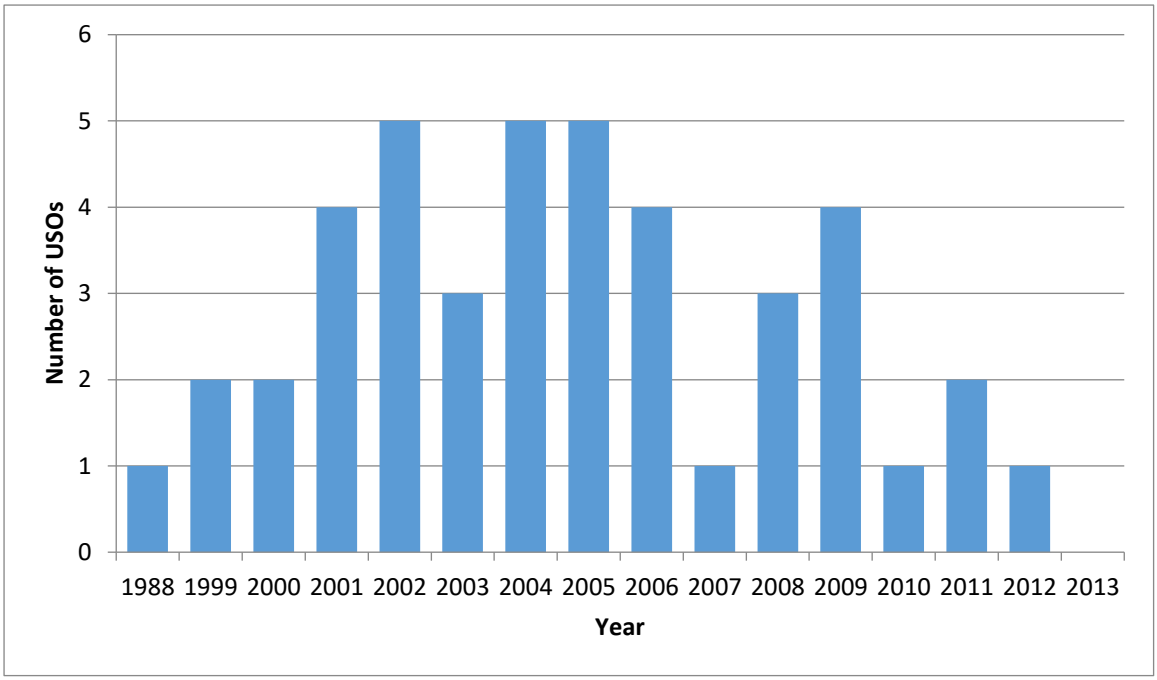


Figure 6.9: UoW USOs, total population, number by year

In arriving at the final population of USOs, as with the UoB, it became clear that none of the four sources would have been sufficient by themselves to give an adequate reflection of the true USO population. This again highlights the need, in order to obtain an accurate dataset, not to rely on one source and to check it thoroughly against published financial data.

6.4.2 Results

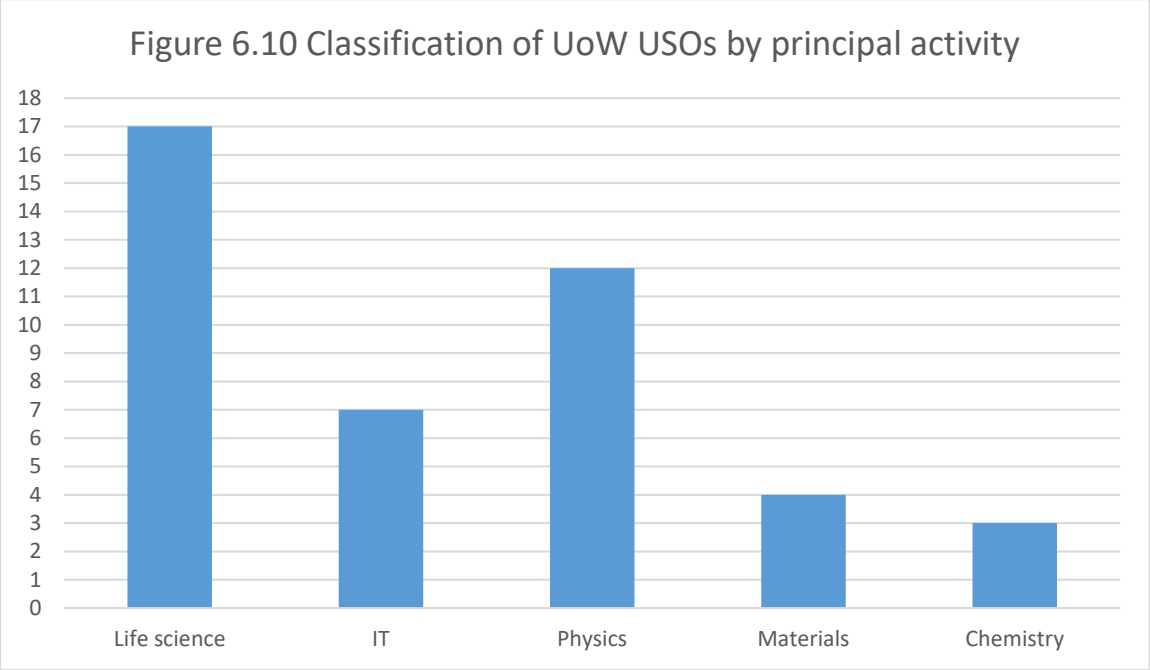
The table below (Table 6.31) shows basic classification data for the USOs obtained from the sources noted above, and summarized in Figure 6.10.

USO name	Company registration number	Principal activity	Classification
Allinea Software Limited	6871298	Develop software tools	IT
Anvil Semiconductors Limited	7300225	Develop silicon carbide technology	Materials
A2SP Limited	5803762	Provision of chemical genomics services	Life science
Base4 Innovation Limited	6389614	Develop single molecule analysis technology	Life science
BioAthene Limited	4928253	Testing and analysis	Life science

Biotek Limited	3796916	R&D	Life science
Circadian Solar Limited	4821641	Develop technology for solar semiconductors	Materials
Clinvivo Limited	8340814	Data processing	IT
Concurrent Thinking Limited	7053109	Support HPC cluster installations	IT
Digeprint Limited	4182191	Photographic activities	Materials
Gadametric Limited	5184524	Develop antiviral screening technology	Life science
goHDR Limited	6804791	Development of algorithms	IT
G-Tronix Limited	5166888	Develop imaging techniques	Physics
Herfurth Laser Technology Limited	3817905	Develop laser technology in the plastics industry	Physics
Incentec Limited	5092146	Develop pre-eclampsia diagnostic	Life science
Microbial Systems Limited	2283069	Biochemical R&D	Life science
Molecular Solar Limited	6769874	Develop photovoltaic technology	Materials
Multimetaphase Limited	4460197	Human health R&D	Life science
Neurosolutions Limited (parent Sevco 5023)	4199343	Electrophysiological services	Life science
Novolytics Limited	4355698	Develop solutions for bacterial resistance	Life science
Opscape Limited	5385726	Develop data visualization software	IT
Optical Antenna Solutions Limited	5774230	Optical R&D	Physics
Prospero Therapeutics Limited	5677134	Life science R&D	Life science
Recycling Technologies Limited	7528795	Commercialise plastic recycling technique	Chemistry
Sarissa Biomedical Limited	4581254	Develop novel biosensors	Life science
Septegen Limited	4152221	Life science R&D	Life science
Shibden Technologies Limited	5604033	Life science R&D	Life science
Sonemat Limited	5521464	Develop ultrasonic testing equipment	Physics
Sorption Energy Limited	6791484	Develop adsorption air conditioning	Physics
Streamline Computing Limited	3913912	Create computer clustering solutions	IT
Tangent Reprofiling Limited	6704572	New uses for old drugs	Life science
Therapro Systems Limited	5019013	R&D healthcare monitoring devices	Physics
Virabiotech Limited	5891056	Develop protecting virus	Life science
Vizeye Limited	6530669	Develop ophthalmoscope	Physics
Warwick Analytical Software Limited	7724630	Develop algorithms	IT
Warwick Audio Technologies Limited	4451674	Develop flat loudspeakers	Physics
Warwick Effect Polymers Limited	4182449	Develop novel polymers	Chemistry

Warwick Insect Technologies Limited	5356603	Develop insect technologies	Chemistry
Warwick Laser Systems Limited	4966131	Develop industrial laser systems	Physics
Warwick Moulding Technology Limited	3990241	Develop anti-counterfeiting technology	Physics
Warwick Plant Genomic Libraries Limited	5044892	Develop plant genomic library	Life science
Warwick Sensor Technologies Limited	4617515	Ultrasonic sensor R&D	Physics
Warwick Warp Limited	5568627	Develop advanced fingerprint solutions	Physics

Table 6.31 Basic classification of UoW USOs



As for UoB, USOs seeking to commercialise technologies within the fields of life sciences and IT (information technology) comprise a significant number of those originating from UoW, a feature commonly observed in studies at other universities e.g. Oskarsson and Schläpfer (2008). UoW also has a large number of physics-based USOs which may reflect the relative strength of its physics departments in terms of generating commercialisable technology.

6.4.3 Survival measurements

Dates of incorporation and dissolution (where relevant) were obtained for each of the USOs from Experian Corpfin and are tabulated below.

USO	Date of incorporation	Date of dissolution	Time to failure (months)	Third party funding?
Allinea Software Limited	6/4/09			Y
Anvil Semiconductors Limited	30/6/10			Y
A2SP Limited	3/5/06	8/9/09	40	N
Base4 Innovation Limited	3/10/07			Y
BioAthene Limited	10/10/03	12/7/11	93	N
Biotek Limited	28/6/99			N
Circadian Solar Limited	4/7/03			Y
Clinvivo Limited	24/12/12			N
Concurrent Thinking Limited	22/10/09			Y
Digeprint Limited	19/3/01	19/5/11	122	Y
Gadametric Limited	20/7/04	13/8/08	48	N
goHDR Limited	28/1/09			N
G-Tronix Limited	30/6/04			N
Herfurth Laser Technology Limited	2/8/99	5/5/06	81	Y
Incentec Limited	2/4/04	23/2/10	70	Y
Microbial Systems Limited	2/8/88	24/1/07	221	Y
Molecular Solar Limited	10/12/08			Y
Multimetaphase Limited	13/6/02	23/10/06	52	Y
Neurosolutions Limited (parent Sevco 5023)	12/4/01			N
Novolytics Limited	18/1/02			Y
Opscape Limited	8/3/05	21/9/10	66	Y
Optical Antenna Solutions Limited	7/4/06			Y
Prospero Therapeutics Limited	17/1/06	5/5/09	39	N
Recycling Technologies Limited	14/2/11			Y
Sarissa Biomedical Limited	4/11/02			Y
Septegen Limited	1/2/01	13/2/07	72	N
Shibden Technologies Limited	26/10/05	21/12/10	61	Y
Sonemat Limited	28/7/05			N
Sorption Energy Limited	14/1/09			Y
Streamline Computing Limited	26/1/00	4/2/14	168	Y
Tangent Reprofiling Limited	23/9/08			Y
Therapro Systems Limited	19/1/04	9/10/07	44	N
Virabiotech Limited	31/7/06	5/10/10	50	N
Vizeye Limited	11/3/08			Y
Warwick Analytical Software Limited	1/8/11			Y
Warwick Audio Technologies Limited	20/5/02			Y
Warwick Effect Polymers Limited	19/3/01			Y

Warwick Insect Technologies Limited	8/2/05			N
Warwick Laser Systems Limited	17/11/03			N
Warwick Moulding Technology Limited	11/5/00	3/11/09	113	N
Warwick Plant Genomic Libraries Limited	16/2/04	27/4/10	74	N
Warwick Sensor Technologies Limited	13/12/02	26/5/09	77	N
Warwick Warp Limited	20/9/05			Y

Table 6.32 Survival data for UoW USOs

As noted above, 43 USOs in total were identified with dates of incorporation ranging from 1983 to 2010. Of the 43 USOs identified, 19 had been formally dissolved. This represents an aggregate failure rate of 44%, although three of the USOs survived for 10 years or more, which is a significant lifespan for a company.

As with UoB, a number of 'twilight USOs' were identified during the data collection. While an element of judgment has to be made as to whether a company has ceased to trade, a further 9 companies (21% of the sample) were identified as twilight USOs. The population's total effective aggregate failure rate is thus 65% (28 out of 43 USOs). Table 6.33 below reveals the identity of the twilight USOs, as well as the rationale behind their designation as such.

USO	**Rationale for 'twilight' designation**
Biotek Limited	Little activity
goHDR Limited	No external investors and little activity
Optical Antenna Solutions Limited	Little activity
Sarissa Biomedical Limited	Last investment 2010 little activity now
Sonemat Limited	No external investors and little activity
Sorption Energy Limited	Last investment 2010 little activity now
Vizeye Limited	Last investment 2010 little activity now
Warwick Insect Technologies Limited	No external investors and little activity
Warwick Laser Systems Limited	No external investors and little activity – may be a consulting company

Table 6.33: Rationale for 'twilight' designation

As with UoB, comparison of UoW USOs' survival rates with existing academic studies of USO financial performance reveals a number of interesting findings. In general, it is clear that this study shows a lower rate of survival amongst USOs than most other studies e.g Oskarsson and Schläpfer (2008) when considering only formally dissolved USOs (46%), and a significantly lower rate than all other studies identified in the previous chapter if 'twilight USOs' are included (35%), which again implies that 'twilight USOs' are an important class of USO that may shed some light upon the apparent longevity of USOs compared to other start-up companies as noted in the academic literature to date. This finding is not in line with signalling theory as UoW is a strong, research-

focussed university with an international reputation, and should be attractive to potential investors leading to longer survival times of its USOs. This observation will need to be considered in greater depth in Chapter 7.

6.4.4 Third party investment results

Table 6.34 below shows which of the UoW USOs obtained external third party funding and the amount of such funding received by each company. The data on funding was obtained primarily from analysis of USO accounts, particularly from review of the share premium account movements, which represent the excess amount of the total investment by an investor over the nominal value of the share capital acquired.

USO	Amount (£)
Allinea Software Limited	450,021
Anvil Semiconductors Limited	1,589,746
Base4 Innovation Limited	5,790,000
Circadian Solar Limited	14,600,000
Concurrent Thinking Limited	2,861,000
Digeprint Limited	4,186,147
Herfurth Laser Technology Limited	187,500
Incentec Limited	448,683
Microbial Systems Limited	4,527,000
Molecular Solar Limited	154,996
Multimetaphase Limited	161,250
Novolytics Limited	2,227,773
Opscape Limited	79,734
Optical Antenna Solutions Limited	50,000
Recycling Technologies Limited	141,825
Sarissa Biomedical Limited	425,657
Shibden Technologies Limited	50,000
Sorption Energy Limited	13,436
Streamline Computing Limited	3,295,833
Tangent Reprofiling Limited	700,455
Vizeye Limited	50,000
Warwick Analytical Software Limited	162,089
Warwick Audio Technologies Limited	3,367,296
Warwick Effect Polymers Limited	4,739,741
Warwick Warp Limited	1,104,859

Table 6.34: Third party investment attracted by UoW USOs

25 out of 43 USOs received external third party investment which represents 58% of the total population. A total of £51,365,041 of investment was received from third parties which aimed to commercialise Aston IP. Table 6.35 provides more detail on the identities of the investors.

Table 6.35 Identities of external investors in UoW USOs

USO	University Challenge Fund (Mercia Fund)	Other private equity	Companies	Individuals	Other	Detail
Allinea Software Limited	Y	Y				Oxford Gateway Funds 2-4, Oxford Technology 3 VCT plc, Forward Innovation Fund, Advantage Growth Fund
Anvil Semiconductors Limited	Y	Y		Y		Ntensive angel group, Cambridge Capital Group, individual angels, Midven, Minerva Business Angels, Early Advantage Limited Partnership
Base4 Innovation Limited		Y			Y	Meridian Growth Capital LLP, Oxford Technology Enterprise Capital Fund, Royal Society, Torteval Instruments Limited
Circadian Solar Limited	Y	Y				Seven Spires Investments (UK) Limited
Concurrent Thinking Limited	Y	Y		Y		Rockridge Investments SA, The Era Foundation Limited, Advantage Growth Fund, Early Advantage LP, Oxford Gateway Fund 4, Oxford Technology 3 VCT plc, Forward Innovation Fund, Carbon Trust Investments Limited
Digeprint Limited	Y	Y		Y		EMRVCF No 1 Partnership Limited, IGIE Limited, JOBO AG, E-Synergy Early Growth Fund Limited, Advantage Enterprise and Innovation Fund
Herfurth Laser Technology Limited	Y		Y			Herfurth Holdings Limited
Incentec Limited	Y	Y	Y		Y	Oxford Technology 4 VCT plc, Advantage Growth Fund, NESTA, Exomedica Limited
Microbial Systems Limited		Y		Y		Advantage Early Growth Fund

Molecular Solar Limited	Y			Y		
Multimetaphase Limited	Y					
Novolytics Limited				Y		
Opscape Limited	Y					
Optical Antenna Solutions Limited				Y		
Recycling Technologies Limited		Y	Y	Y		Advantage Early Growth Fund, Environmental Integrated Solutions Limited
Sarissa Biomedical Limited	Y	Y			Y	The Wellcome Trust, Advantage Growth Fund
Shibden Technologies Limited		Y				Rising Stars Growth Fund
Sorption Energy Limited		Y		Y		H2O Venture Partners
Streamline Computing Limited	Y	Y				Oxford Technology 3 VCT plc, Midven, Advantage Growth Fund, Forward Innovation Fund
Tangent Reprofiling Limited			Y			PepTcell Limited
Vizeye Limited				Y		
Warwick Analytical Software Limited				Y		
Warwick Audio Technologies Limited	Y	Y		Y	Y	IBL Associates Limited, Finance Wales, Midven, Minerva Capital, Porton Capital, Synergis Technologies Limited, Exceed Partnership LP
Warwick Effect Polymers Limited	Y	Y		Y		Catapult Venture Managers, Seven Spires Investment, Oxford Technology VCT 3-4, Midven, Advantage Growth Fund
Warwick Warp Limited		Y				Porton Capital Technology Fund

Given the number of investors and funding rounds, it was not always possible to identify the amount invested by each investor as such data was not publicly available.

These findings are exactly in line with both signalling and agency theory. UoW has attracted significantly more funding for its USOs in the UK than any other university in the region, which may be ascribed to the strength of its technology commercialised by its USOs and the strong signals given to investors. The wide range of investors is in line with agency theory which predicts trust will build between a TTO and investors once USOs that attract funding have been generated. The data therefore confirms the significance of the research strength of the parent university in obtaining funding for its USOs.

6.4.5 USOs achieving an exit

Of the 43 UoW USOs, 2 led to a successful exit for shareholders via a trade sale of the entire share capital to a third party. None of the USOs offered any shares to the public via a stock market listing.

A detailed analysis of the two USOs was undertaken through review of their financial accounts and other publicly available information to provide more details about the nature of the trade sale and whether the terms of the sale were beneficial to UoW.

6.4.5.1 Neurosolutions Limited

This USO was founded in 2001 with the aim of commercialising UoW technology as a specialist service business exploiting a niche biopharmaceutical market by providing clients with highly specialized contract electrophysiological research. Electrophysiology is a specialised technique used to record electrical activity in biological systems, and is essential to neurological drug discovery and development. UoW held an equity stake of 15,000 shares with a number of university academics holding another 72,100 shares between them. No external funding was obtained for the company which quickly became cash-generative and self-funding.

In August 2005 the entire share capital of the company was sold to NeuroDiscovery Limited, an Australian company formed in April 2005 for the purpose of the acquisition, and which subsequently listed on the ASX (Australian) Stock Exchange. The total consideration was 3,391,667 Australian dollars which consisted of the fair value of shares in the acquiring company. UoW received its share of the consideration i.e. £248,553 (using the prevailing exchange rate of 2.35 Australian dollars to Sterling).

At the last published accounts prior to the date of sale the USO had net assets of £232,584 and a positive profit and loss reserve of £231,284, an indication that the company was profitable and cash-generative at this stage.

It is not clear how much value UoW was able to realise from its shareholding. NeuroDiscovery Limited is still trading although its name has changed to Oncosil. UoW's accounts appear to indicate that its shareholding of 3,469,187 shares was disposed of during the year ended 31 July 2010. During this year, the stock price of NeuroDiscovery was consistently around the 0.05 Australian dollar mark, implying a value of about £173,000.

In an unusual turn of events, the management team of Neurosolutions subsequently reacquired the entire share capital of the company from NeuroDiscovery in 2010, supported by UoW. The total consideration paid was £515,300 (significantly less than the original purchase price). It is likely that UoW's shareholding in NeuroDiscovery was used to fund its acquisition of shares. Overall, therefore, it seems unlikely that UoW has made any financial return from this USO.

6.4.5.2 Warwick Effect Polymers Limited

This USO was founded in 2001 to commercialise technology around the development of novel polymers developed at UoW. Funding of £4,739,741 was received from a numbr of investors including the Mercia Fund, individuals and private equity investors such as Seven Spires Investments, Catapult Venture Managers and Oxford Technology VCT 3. UoW transferred IP to the company in exchange for 4,663 £1 shares. Other investors held 212,357 £1 shares.

In January 2012 the entire share capital of the company was acquired by Polytherics Limited for £1,050,000, apparently primarily via a share for share exchange. On a pro-rata basis, UoW would have received value of £22,561 in return for its stake. Review of the subsequent annual returns of Polytherics do not indicate any shares owned by UoW, so it would seem that UoW received cash for its small stake. Polytherics subsequently listed on the UK's AIM stock exchange via its holding company Abzena plc in 2014, so UoW would not appear to have benefited financially from this subsequent activity.

In the last published set of accounts prior to the date of acquisition, the USO had positive net assets of £90,711 and a profit and loss deficit of £4,866,050, showing that the company was still in the development phase with respect of its technology. At this point, the company had effectively run out of money to further develop the technology, so Polytherics was paying what it deemed to be the market value of the technology.

Although the technology developed at UoW was clearly of value, and attracted external investment over a number of years, the UoW did not benefit financially to any significant degree as it was further developed.

These findings are not in line with signalling theory, especially as initial funding was so successfully obtained by UoW for its USOs. This would have been expected to carry on for further rounds. At this stage it is difficult to explain this observation, but it may be that the underlying technology was not actually of high enough quality to commercialise, despite the investment success. This observation clearly demonstrates that information asymmetry can persist for a TTO and investors to a very late stage in the process of a USO's lifecycle, and that trust as discussed under agency theory can be misplaced, with investors unable to provide suitable due diligence on USOs in their early life and relying on signals from other investors to aid their decisions to invest.

6.5 Summary

UoW shows a number of factors amongst its USOs which will bear further discussion in Chapter 7. The USOs have been by far the most successful in terms of external investment achieved in the region, which is in line with the framework of signaling and agency theories based on the university's strong research capability, as demonstrated by its membership of the Russell Group. However, the increased level of funding does not appear to translate into long survival times or financially

successful exits, which seems to be inconsistent with the predictions of the frameworks considered given the research expertise of the institution. Clearly, financial performance is a complex area to assess, but the accurate data obtained from this work across a range of universities will allow the predictions of signaling and agency theory frameworks to be evaluated as to their accuracy with some confidence.

Chapter 7: Analysis of Results within the West Midlands region

Introduction

The previous two chapters presented and summarised the secondary data collected during this piece of research to be used in the analysis of the financial performance of USOs derived from universities based in the West Midlands. In this chapter the data is analysed in more depth to provide comparisons between USOs from the universities examined in the current study, while Chapter 8 compares them with other USO financial performance studies in the academic literature. Chapter 6 identified three different categories of university within the region, namely Russell Group universities which are heavily research-focussed, Plate Glass universities which often obtained university status during the 1960s, and Post-92 universities which obtained similar status after 1992, and which are often less research-intensive. These categories will be of use in the analysis of the regional data.

The three datasets collected for each university cover basic descriptive USO data, survival data and third party investment data. In addition, data is collected on the success of USOs as measured by the sponsoring university's financial returns upon exiting its investment. The theoretical frameworks identified in Chapter 3 as having some relevance for this work, namely signalling theory and agency theory, are used to evaluate consistency of the data with their predictions where possible in order to attempt to provide theoretical justification for the results and conclusions drawn from the analyses, serving to advance the academic literature in this area.

On first principles, signalling theory would predict that universities of greater research strength would generate more technologies that would have potential to be commercialised. This would then lead to more USOs being created, and more external funding being attracted given the strong signal of the parent university's reputation and research strength (Meoli *et al*., 2013; Munari and Toschi, 2010; Soetanto and Geenhuizen, 2015). As a result, the USOs from such universities should survive for longer (Conceicao and Faria, 2014) and see more successful exits. However, this analysis may be simplistic, and as already discussed, the links between research strength of a university and the number of USOs generated remains disputed. Further, the link between the attraction of external finance and the subsequent financial performance of a USO may also not be straightforward.

Agency theory might be expected to predict that USOs that obtain external funding perform better from a financial perspective as the goals of investors and management become aligned. This would complement the predictions of signalling theory, and may mean that it would be difficult to separate the two. Again, however, the behaviour of different parties is a complex model and goal incongruence may still occur after funding.

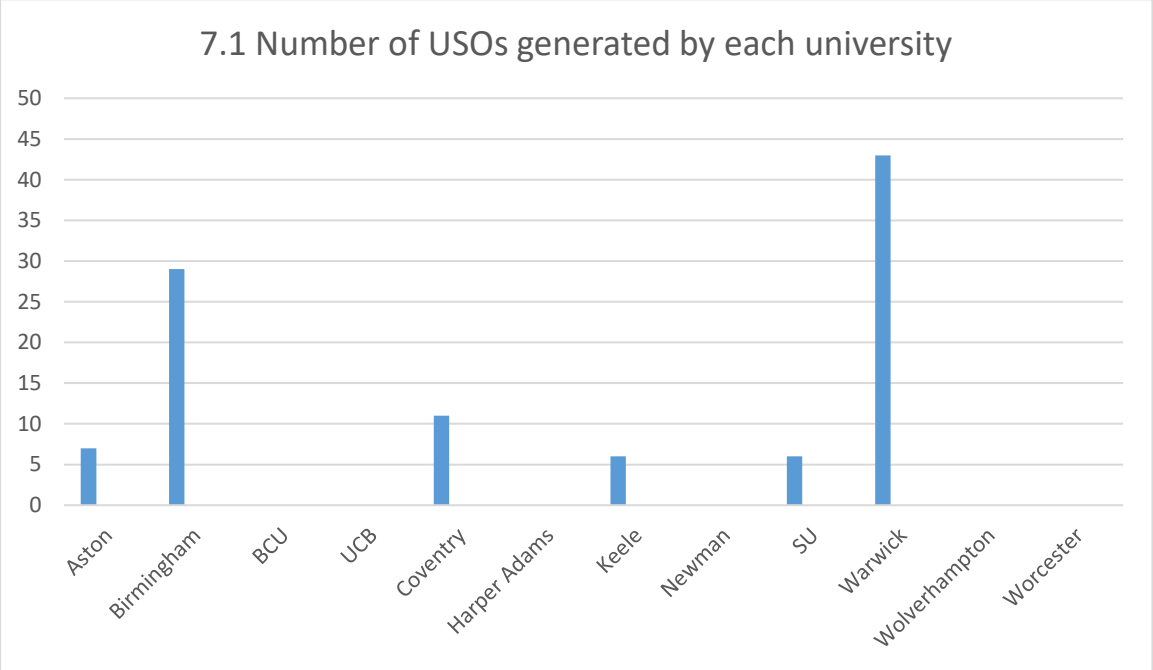
Both theoretical frameworks may also be impacted by the fundamental concepts of information asymmetry and uncertainty, which are important in the world of USOs, and which may serve to distort the above analysis.

7.1 Classification data

The basic classification data for USOs previously collected includes the number and date of formation of USOs generated by each university in the region, and at a company level the principal activity of each USO.

7.1.1 Number of USOs

The number of USOs generated from each university for all years from 1983 up to and including 2013 was obtained from up to four key sources: the commercial databases of Experian and Spinouts UK, the university's annual accounts and the university's TTO website. The results are presented in Figure 7.1 below:



Analysis

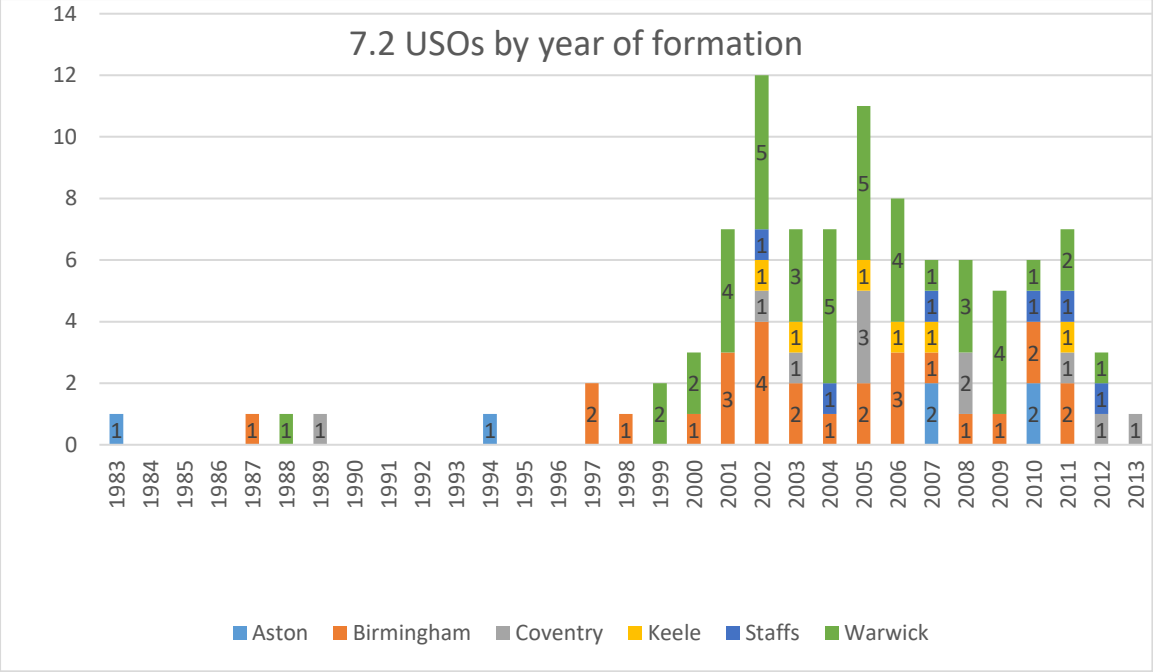
The disparity in USO generation amongst these universities invites comment. Six universities in the region (50% of the population) did not create any USOs at all, which is in line with Pressman's (2002) work that found 36% of US academic institutions did not generate any USOs, and Benneworth and Charles (2005) who identified a clearly uneven distribution amongst UK universities. It is noticeable that these universities are all Post-92 universities and the majority do not teach or perform significant levels of research in the academic areas which have historically given rise to the majority of USOs in the UK, namely science, engineering and information technology, so this result may be as expected. However, given that the current study does not attempt to limit the definition of a USO in any way based on the university department associated with its origins, it is clear that these institutions have not chosen USO creation as a means of attempting to commercialise any of their research. Of course, it is entirely possible that these universities have developed their entrepreneurship profile in different ways, and whether the USO route is necessarily the best from a financial perspective for the associated university is an important topic under discussion in this work. From a policy perspective, therefore, it is clear that at least in the West Midlands region the subject of USOs is not of significant importance to anything like the majority of universities.

Of those universities in the region that undertook programmes to create USOs, Birmingham and Warwick created significantly more companies than the others. At first viewing this result may not be surprising, as these two universities are the region's only members of the Russell Group, a grouping of the most research-intensive universities in the UK, and both have a long established research tradition in science, technology and engineering. Both universities have clearly embraced the proposal that USO generation is a significant part of helping them to achieve their 'third mission'. This finding is consistent with signalling theory (Connelly *et al*., 2011), which would predict that significant amounts of high quality underlying technology will attract TTOs and inspire them to set up USOs to undertake commercialisation, and is consistent with the findings of some prior studies e.g. DiGregorio and Shane (2003).

However, the relationship between the nature, quality and heritage of research performed at a university and the quantity of USOs that it generates is not necessarily a simple one and a range of factors may need to be considered to determine a convincing explanation of trends (Rasmussen and Borch, 2010; RSC, 2005). Some of the other Plate Glass and Post-92 USO-generating universities in the region have traditions of being founded upon research and training in scientific-related disciplines, as noted in the brief histories provided in the previous chapter. Aston in particular is an interesting case: it was founded as a College of Advanced Technology and still performs very significant amounts of research into science and technology, and as discussed below actually has a very early history of commercialising its technology. However, the number of USOs it actually generated is quite low, significantly fewer than the Russell Group members, and even than some of the much more modern universities with less heritage in these fields. Clearly, the decision to undertake a programme of USO creation is not necessarily a straightforward one, and the case of Aston may illustrate that certain universities were unconvinced that it was the best way to proceed in terms of achieving their commercialisation aims. This finding of a significant degree of complexity in the relationship between a university's research capabilities and the number of USOs that it generates is exactly in line with previous work e.g. Tornatzky *et al*. (1997), as laid out in Chapter 2. This topic is discussed in more detail below at 7.1.4.

7.1.2 USO formation by year

Figure 7.2 below combines data collected in the previous chapters for each individual university showing the year of incorporation of their identified USOs, allowing comparisons to be drawn between universities across the region, as well as the response of the region as a whole to any external influences.



Analysis

Figure 7.2 reveals a number of particularly interesting features that show the potential impact on USO formation of a number of external factors, which may also be relevant to other regions of the UK. Firstly, it is clear from the above diagram that commercialisation of technology by universities was being undertaken well before the significant growth in USO numbers in the region from around the year 2000. Although numbers of USOs formed during this early period were very small, this is likely to have been a consequence of universities, in the absence of readily available external funding during the period up to around the year 2000, carefully selecting those technologies which were considered likely to provide a financial return. This is an aspect of the USO debate that is consistently overlooked or ignored during the relatively recent popularisation of USOs by national governments and other interested parties. Other academic studies have noted similar early developments of USOs in the UK e.g. Lawton Smith and Ho (2006), Segal Quince and Partners (1985) when considering the Universities of Oxford and Cambridge respectively, and Lawton Smith *et al*. (2014) who identified a USO formed from the University of London in 1965.

Secondly, it is evident that the rate of formation of USOs dramatically increased from about the year 2000. This can be reasonably be attributed to the introduction of University Challenge Funds (UCFs) by the UK Government, within the wider framework of encouraging USO formation specifically in the context of increasing university technology commercialisation. The background to UCFs has been covered in an earlier chapter, but these were funds backed by government money specifically set up to provide funding, via equity investment or loans, to USOs. This policy was an attempt to overcome a perceived problem, common to all start-up companies trying to commercialise new technology, of being able to find external funding to provide support during the development of the technology to a stage where the USO can start to receive income. This so-called 'funding gap' largely arises due to the unwillingness of external investors such as venture capital to invest relatively small amounts of money into companies where the technology is often speculative and unproven (Manigart and Wright, 2013). From a UK government perspective, it can be seen that the narrow objective of UCFs to create more USOs was therefore achieved.

The peak year of USO formation in the period under review is 2002, which corresponds to a relatively short time period after 2000 when universities probably became sure that UCFs were ready and able to provide funding, and gained familiarity with the funding process. Oskarsson and Schläpfer (2008) note that during the period between 2002 and 2007, 80% of new USOs each year received some form of equity participation from the UCFs, which clearly highlights that this was a critical factor in increasing the number of USOs generated during this period.

It is then interesting to note that the rate of USO formation fell relatively sharply in 2003 before climbing slowly to another peak in 2005. This trend has already been noted and explained by various commentators. The Finance Act of 2003 introduced by the UK Government included a provision known as Schedule 22 (Minshall and Wicksteed, 2005). Its purpose was to prevent the increasing practice, largely instituted by private equity and other financial institutions, of paying their employees in shares and thus reducing their personal tax liability when compared to being paid extra salary or a bonus. Schedule 22 required a valuation to be placed upon such shares and income tax was then often charged upon this value, negating the above tax planning. However, probably unwittingly, this provision would also have applied to academics who received shares in USOs that were incorporated to commercialise their technology, providing them with a financial incentive should the venture ultimately succeed. In the financial climate at the time, valuations which later proved to be excessive were placed upon all kinds of start-up companies, including USOs, which lead to the apparent prospect of academics of moderate means being subject to a significant income tax charge without having received any cash with which they could pay the tax. As a result, a number of potential USOs were apparently delayed in their creation due to anticipated adverse tax consequences as a result of a political policy decision.

It is not clear whether any academic ever actually paid any such income tax, and it can also be seen that USO formation continued, although at a reduced rate. The UK Government did eventually legislate to provide an exemption to academics from the provisions of Schedule 22, which came into effect in 2005. In addition, it should be noted that the valuations of USOs being claimed in this period proved, almost without exception, to have been significantly higher than ever actually realised, and indeed most USOs provided no financial benefit to any of their shareholders at all, as will be seen later in this study. Once the new 2005 legislation was promised and then enacted, the number of USOs climbed briefly, presumably as delayed formations were pushed through.

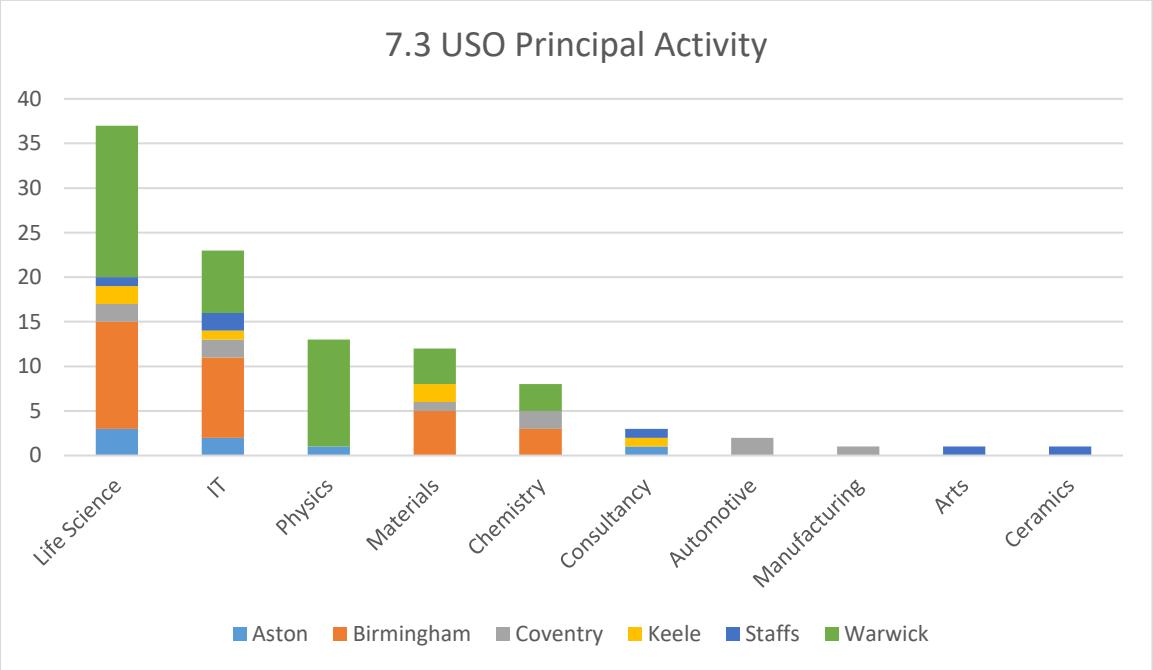
In the years following 2005, the rate of USO formation fell back, probably as the UCFs' funding was exhausted and not replenished, and universities and external investors started to realise that most USOs were not providing any prompt financial return upon their investment. The numbers of USOs formed in the West Midlands region from 2006 to 2011 are relatively constant. This would be in line with both signalling and agency theory in that the lack of successful USOs to date increased the uncertainty for potential funders, who reduced their appetite for funding such companies, with universities responding by changing their USO creation policy by focussing on smaller numbers, although there is no such official policy change that has been recorded in the literature. After 2012 the rate of formation again fell sharply, and universities appear to have gone back to pre-2000 patterns of USO generation i.e. as and when a technology genuinely capable of commercialisation was developed. There may also be an underlying impact of the credit crunch of 2009 and the associated recession, although the impact is not immediate, and this may well partly be due to the time taken to develop a technology ready for a USO and the time period necessary to form a USO.

Finally, it is also of interest to comment briefly upon the different USO formation policies of the universities as evidenced by Figure 7.2. Aston has a long pedigree of creating a small number of USOs, presumably as and when a potentially readily commercialisable technology was developed,

and this behaviour was not apparently greatly changed by the new availability of UCF money. By contrast, Warwick created very few USOs before UCF funding became available, but then created large numbers of USOs, which required significant investment in its technology transfer operations. Birmingham has an approach between these two extremes, with some pedigree of USO creation through its own resources, but additionally taking moderate advantage of UCF money to increase its USO formation rates. Coventry, Keele and Staffs had little pedigree of USO formation before 2000, but then created a body of USOs on a much smaller scale than Birmingham, rarely exceeding a formation rate of over one per year. These differing behaviours of university administrators with regard to USO formation rates highlight a significantly overlooked situation that the acceptance of USOs as the premier method of technology commercialisation was by no means uniform, even within a geographical region, and it would be interesting to examine the decision-making processes at each of the universities in question throughout this period should such data exist and be readily available. Agency theory would recognise that different TTOs may have very different goals for their USO programmes, which can potentially lead to conflict with external parties, so this finding is in line with that forecast.

7.1.3 USO Principal Activity

Figure 7.3 below displays the principal activities of USOs formed in the region, and allows comparisons to be made between universities as to the nature of USO they preferred to form.



Analysis

As expected, principal activities of USOs created are dominated by the areas of science (encompassing engineering across various sectors) and information technology, since these are the areas of research which lend themselves to producing a range of new technologies, some of which may be commercialisable. In addition, these are areas where universities could potentially have a competitive advantage over the private sector given their ability to investigate areas that do not require an immediate profit motive, as well as their resources of availability of highly skilled researchers and the range of existing knowledge that they hold. In particular, life sciences and

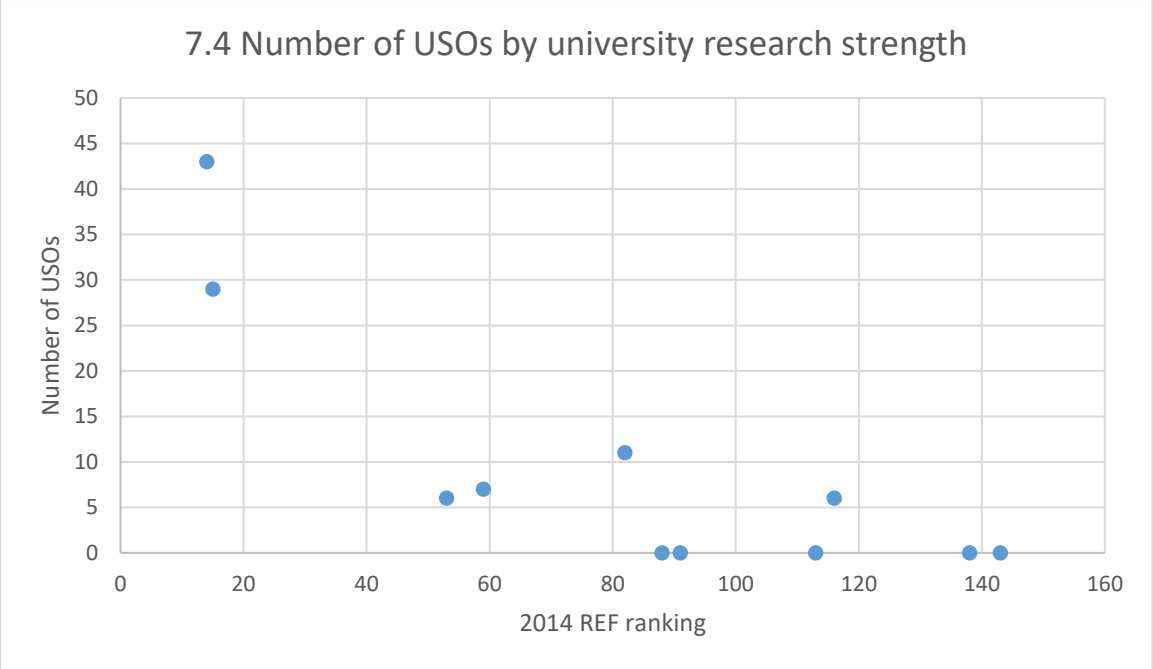
information technology are the two most significant areas for USO formation. Life science is an area in which some universities can excel, particularly given their ability to utilise existing laboratory facilities and their links with connected medical facilities. This finding is in line with other studies e.g. BVCA (2005) which found in its review of UK USOs that 46% of its sample focussed on life sciences and 39% on information technology, and Oskarsson and Schläpfer (2008) who found that 54% of 130 ETH Zurich USOs fell into these two categories, which they consider to be a mainstream area of focus for venture capitalist investment, a finding replicated by Visintin and Pisano (2014) who found 53% of their sample of Italian USOs were similarly categorised. In their study of USOs from Oxford University, Lawton Smith and Ho (2006) found that life sciences accounted for 39% and IT for 29% of their sample, while Lawton Smith *et al*. (2014) found at the University of London 40% in pharmaceuticals/biotechnology and 17% in software and computer sciences.

Minshall and Wicksteed (2005) found in their study of USOs from UK universities that while the combination of these two sectors accounted for most of the USOs for each university, the proportions varied. Their first group of universities with the largest research budgets comprising Oxford, Cambridge, Imperial College and University College London had 47% of its USOs in life sciences and 40% in physical sciences (which incorporates IT). Their second group of universities designated as large universities in major cities and including Edinburgh, Southampton and Newcastle had 31% in life sciences and 58% in physical sciences, while the third group comprising universities with smaller research budgets (Cranfield, Loughborough and Strathclyde) had 16% in life sciences and 80% in physical sciences. It may be that life sciences are therefore the preserve of institutions with large research budgets given the heavy facilities expenditure necessary to develop technology in this sector.

These findings are in line with both signalling theory, in that universities with proven experience in research in certain fields is a strong signal that will attract funders for USOs based upon these technologies, and agency theory which forecasts that success in such fields builds trust with potential and existing funders. The perceived existing expertise will also help potential funders to overcome uncertainty and information asymmetry during the due diligence process.

7.1.4 Number of USOs by research strength of university

Figure 7.4 below shows the number of USOs created by each university in the West Midlands compared to its research strength. The research strength of a university is taken from data collected under the UK's 2014 Research Excellence Framework (REF) and analysed by Research Fortnight magazine to create a ranking system for UK universities (Research Fortnight, 2014). The REF received data from 154 UK universities and assessed their research for its quality. Research Fortnight then weighted the data to reflect the number of research staff to produce a ranking table for UK universities.



Analysis

The results above show a very broad trend in that universities with a high research strength i.e. Warwick and Birmingham, form significantly more USOs than universities with a low research strength. This finding is not in line with earlier studies in the US e.g. Tornatzky *et al*. (1997), Shane (2004) which found no correlation between the two. However, the results of this study should be treated with care as the sample size is very small. On first principles, the theoretical frameworks considered in this work would tend to support a positive correlation; as already noted, signalling theory might predict that stronger research universities will produce more technology capable of commercialising in the knowledge that funders would find them attractive. However, the university may find other ways to exploit their technology such as licensing, so this analysis may be simplistic. A difference between the current study and earlier US studies is likely to be that the UCFs in the UK were deliberately targeted at USO creation, thus distorting the ratio of USOs to other forms of exploitation, in line with the observations of Lambert (2003). The current study shows that USO formation rates in the UK fell significantly after UCF money was exhausted, which again supports this hypothesis.

7.2 USO Survival

The following section considers the first of the two USO performance metrics used in this study; that of USO survival.

As already noted, the current study will only consider financial resources of a USO given its narrow parameters, so will not provide a full picture which would consider a range of potential resources (Coad *et al*., 2016). The two theoretical frameworks considered in this work have less to add directly towards the interpretation of survival data. Agency theory will be more concerned with a USO's ability to attract finance within the framework of potential conflicts between TTO and potential

investors, while signalling theory also focusses on a USO's attraction of finance due to underlying resources. Indirectly, both models may support attempts to interpret a situation where a USO was able to attract finance and the impact upon its survival.

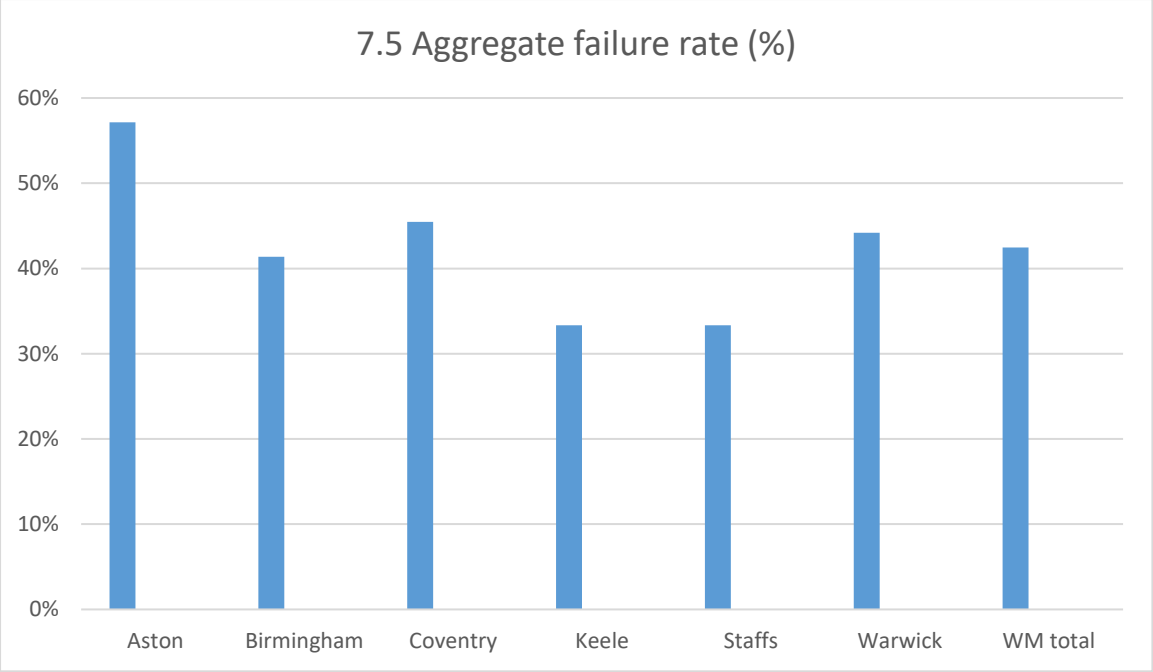
In addition, in line with prior studies e.g. Curran et al. (2016), care must be taken in drawing conclusions over survival rates, as a number of key factors may be at stake, some of which are highlighted in Table 7.1 below. These factors will not be studied in detail in this current work due to the limitations of the data collected, but would be interesting to consider in further work on this topic.

Factor	**Potential impact**
USO industry sector	USOs from certain sectors e.g. life science may last longer as the nature of the technology they seek to commercialise means a longer lifecycle
University resource	USOs from strong, research resource-rich universities may last longer due to higher quality technologies which investors are prepared to support for longer
Ownership structure	USOs with external funders may survive less long due to investors' willingness to cease support quickly once a technology appears unlikely to reach commercialisation
Academic commitment	USOs from universities that allow founder academics to work a significant part of their time in the USO may survive longer as the academic can fully focus on developing the technology
Academic movement	USOs where founders move away from the parent university may survive less long as technology development will slow
TTO attitude to survival	USOs from universities where the TTO has private equity mindset may survive less long for similar reasons as when external investors are involved (see above)

Table 7.1 Factors which may affect survival rates (author-derived)

7.2.1 Aggregate Failure Rate

Figure 7.5 below shows the aggregate failure rate for each university of its USOs. The aggregate failure rate simply divides the total number of USOs that failed for each university (in this case defined as companies that had been formally removed from the company register held at Companies' House) by the total number of USOs founded. It therefore does not make any allowance for time effects i.e. newer USOs are less likely to be have had time to fail. The USOs in the sample may therefore be at very different stages of development and be in possession of very different quantities of resources (Vohora *et al.*, 2004) e.g. there is no control for USOs that have only recently been founded and may not have had time to attract the notice of potential external investors. However, it does have value as a performance metric in that previous studies in the literature have highlighted the relatively long survival times of USOs without attempting to control in this manner e.g. Shane (2004).



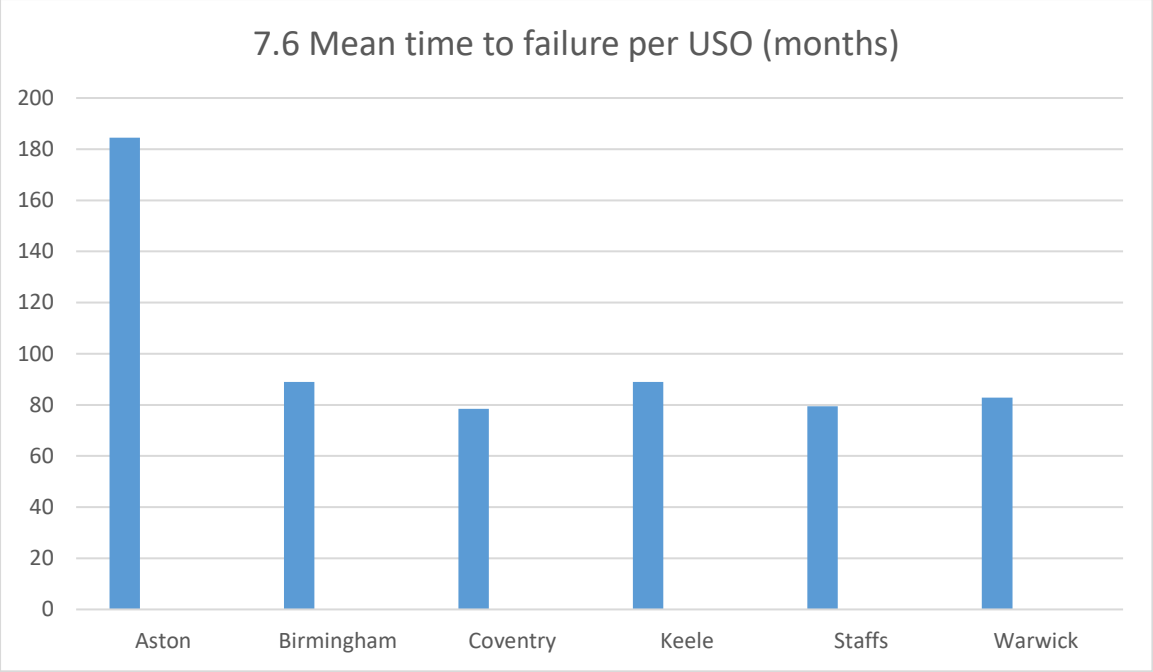
Analysis

The data shows that the aggregate failure rate is relatively consistent over the universities, although as noted above, no allowance is made for the age of the USOs in question. This manifests itself in the performance of Aston, which appears to show a high failure rate, yet as noted in the previous chapter this is not particularly reflective of the true situation as two of the USOs were both over twenty years old before being removed, which is a significant lifespan for a company. On the other side of the coin, the USOs of Keele and Staffs are relatively young in age and hence have had less time to fail, which is reflected in the low failure rates for these two universities.

However, given that USO formation was extremely low in the region before 2000, meaningful comparisons can still be made between universities and the uniformity of the failure rates is notable; this may imply that the universities' technology transfer operations have taken a consistent view in allowing USOs to fail and be removed across a wide range of timescales and population sizes. Given that the financial resources of all the USOs are likely to vary considerably by university, this would go against previous findings that more financial resources increases the likelihood of survival (Shane and Stuart, 2002). This will be explored later in the chapter.

7.2.2 Timed failure rate

In an attempt to augment the data from the aggregate failure analysis to provide a more complete picture, other measurements of survival and failure have been undertaken. The main alternative method of measuring failure rates is to use the timed failure rate method which takes account of the time a USO has been in existence and therefore aids comparability between studies. Figure 7.6 below compares this metric across the universities.



Analysis

The data obtained from using this performance metric is remarkably interesting in that the universities (with the exception of Aston) show a very tight band for the average time it takes a USO to fail from 78 months to 87 months (although these quantities mask significant variations on a company-level basis at each university). This finding would not necessarily be anticipated given the wide range of factors involved such as the attitude of the university TTO towards striking a company off, the amount of any external funding for the USO and the associated relationships with the funder, the fundamental nature of the technology being developed and the position in the economic cycle of the formation date (Simon-Moya *et al*., 2016), which are very different across each company.

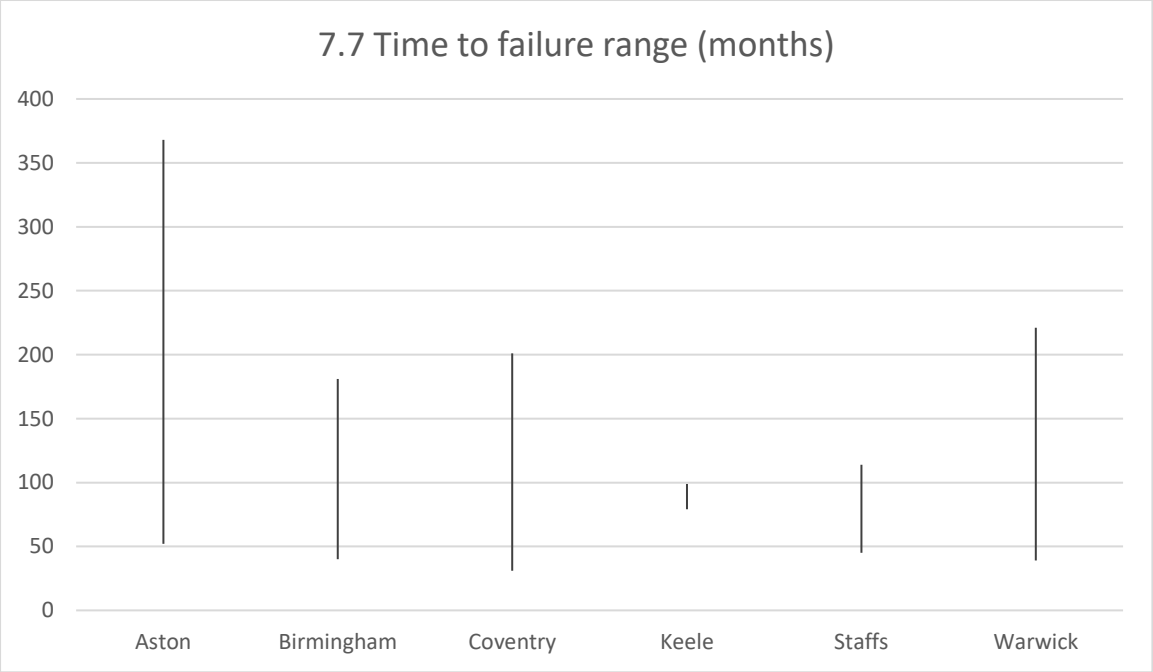
As noted above, Aston's figures clearly demonstrate the effect of two extremely well-established USOs amongst those that have been removed, which confirms the need to look beyond the simple aggregate failure rate in drawing any firm conclusions in a study of financial performance across a number of companies, as a number of studies in the academic literature have failed to do e.g. Shane (2004).

Although comparisons of failure and survival rates with other studies in the literature will be carried out below, a brief comment on the global findings is instructive at this stage. The mean lifetime of a USO in the West Midlands as displayed above is significantly longer than would be expected, and indeed is observed, than a start-up company in the private sector. Cressy (2006) notes that a number of studies of start-ups show that of the order of 50% fail within the first two and a half years of trading. This finding is consistent with a number of other academic studies e.g. Zhang (2009). A number of reasons have been derived for this observation, some of which have been covered in a previous chapter. However, under signalling theory, which would predict stronger research universities obtaining more USO funding and hence longer lifetimes, such a consistent survival time would not be expected. Further investigation will focus upon the financial resources of USOs and the impact upon survival, but this early finding goes against previous conclusions e.g. Mustar *et al*. (2006) mentioned above. It may be that this relatively small sample of USOs has this unusual

property that may not be seen elsewhere, or that stakeholders in the USO, both TTO and USO management, have a surprisingly consistent approach to deciding when to dissolve their company. This may also be an example of a situation observed using agency theory where external financiers are present, in that their goals become aligned with the TTO eventually in deciding when to cease their interest in the USO.

7.2.3 Range of times to failure

The above graphs conceal some wide variations in failure time at each university on a company level, so Figure 7.7 below adds to the overall analysis by displaying, for each university, the range of lifespans of USOs that have been removed.

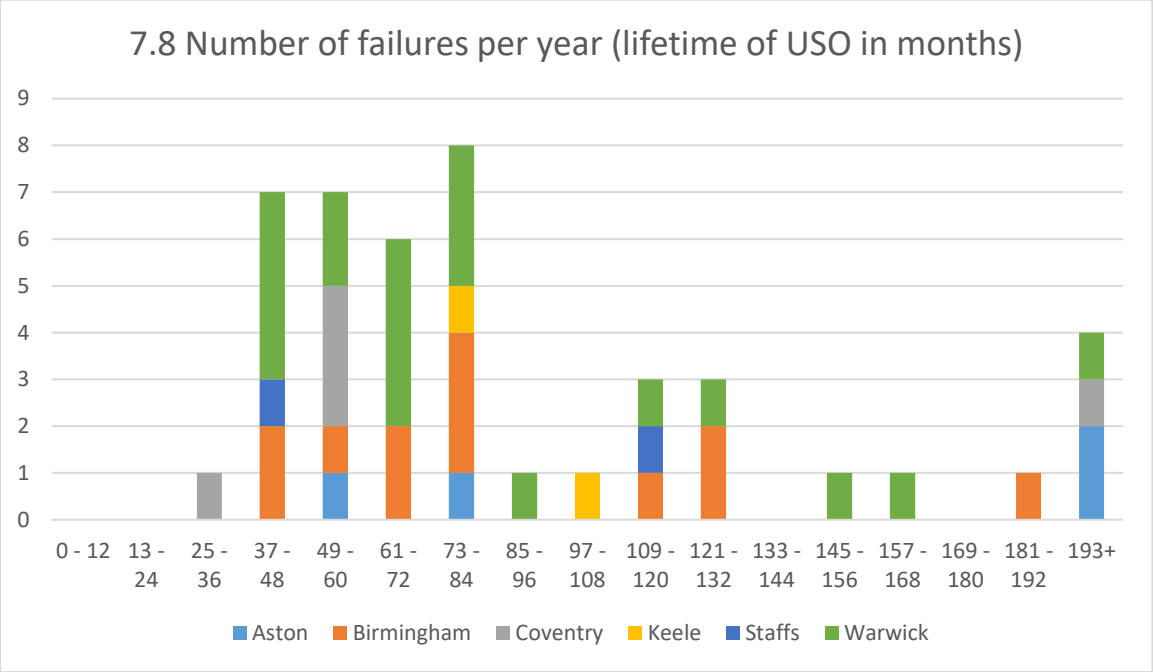


Analysis

A number of interesting points arise from this figure. Aston's established USOs again feature prominently in the results as expected by providing a maximum lifespan significantly in excess of any of the other universities in the region, while Keele shows an extremely narrow range of ages, but this may be explained by the small sample (only two companies ceased to trade and were removed from the record at Companies' House in total). More generally, it is interesting that the shortest lifespan is just under 50 months for five of the six universities, implying that this is the absolute minimum period before those responsible for the USO's administration decide that the technology being developed is not able to be commercialised. As this decision could have been made by a range of diverse parties such as founder shareholders, external investors or university TTOs, this consistency is of interest and is potentially in line with the framework of agency theory where external investors and TTOs see their goals becoming aligned over time (where the USO attracts external investment), although still unusual given the range of parties involved. Given that most USOs were not founded until after 2000, it is not possible at this stage to comment in detail about the upper limits observed for USO lifespans in the region.

7.2.4 Failures per year

Figure 7.8 builds on the range of lifetimes data in Figure 7.6 to show full data for each USO showing the year of its life in which it was removed.



Analysis

The data above shows a number of points of note. Firstly, only one USO out of the whole population was removed before it had been in existence for 36 months. This is a significantly lower rate than the failure rates observed in studies of the wider population of start-up companies (which includes USOs and all other start-up companies), and although such studies provide a wide range of results, amid some concerns about the methodologies used, this is a significant difference. There is, however, a relatively straightforward explanation of this phenomenon in that the underlying nature of USOs will tend to mean that they own an early stage technology that still requires development time and costs before it reaches a stage at which it may be commercialisable. It would therefore appear that the shareholders of USOs are more willing to allow the company time to develop their technology than the wider business community. This is in line with the finding from Figure 7.7. In addition, the nature of USOs may mean that they are more likely to require funding resources from investors to develop their technology, who will be more likely to give the company a chance to succeed and see a return on their investment. de Cleyn (2010) notes similar findings, although concludes that such data covers up underperforming USOs.

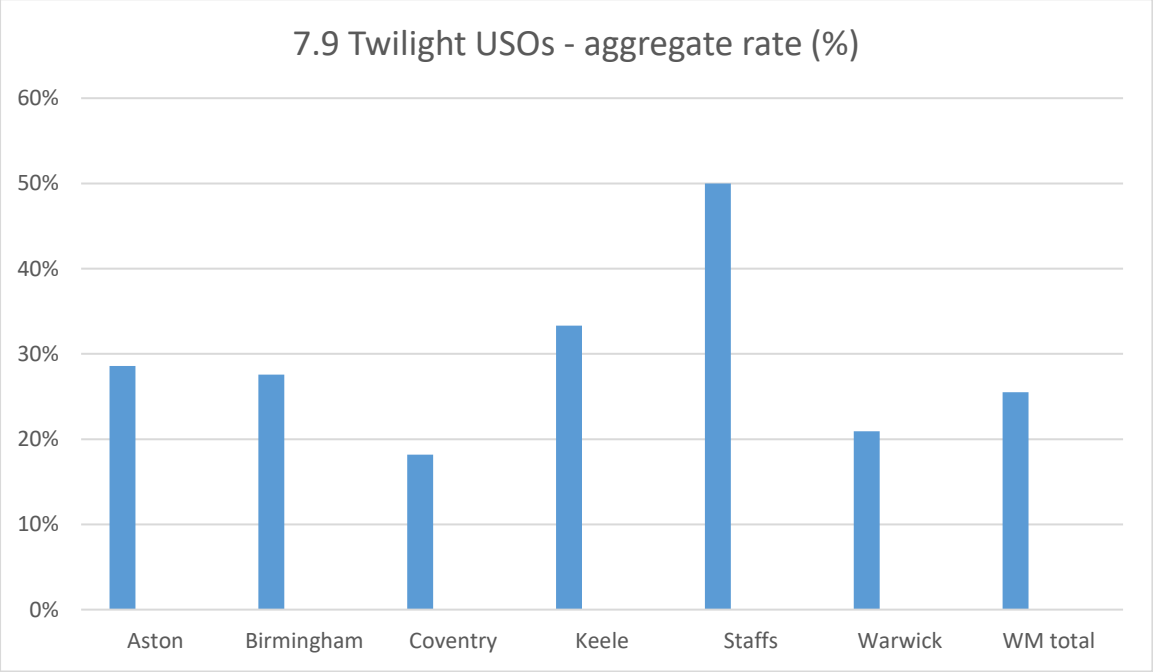
Secondly, it is apparent that the majority of USOs are removed from the Companies' House register within a relatively narrow band of time (in this sample at least). 64% of failures occur between the ages of 36 and 84 months, although this is not a feature that has been noted in the USO academic literature to date. The consistency observed for universities across the region is interesting, particularly given the different attitudes already observed towards the formation of USOs. Clearly 7 years appears to be an important cut-off point; if the technology has not proved to be

commercialisable by this stage then, unless a significant change such as in senior management occurs, it is considered by all significant stakeholders as reasonable to assume that it never will be, and further resources are no longer provided to the USO. Again, for USOs that received external investment, this may demonstrate consistency in goal congruence between investor and TTO within the framework of agency theory. However, studies have shown a range of attitudes amongst external investors in keeping their investments alive e.g. Ruhnka *et al*. (1992), so again this consistency is interesting.

7.2.5 Aggregate Rate – Twilight USOs

As noted in the previous chapter, the discovery of a category of USOs designated 'twilight USOs' is an important finding of this work and one not discussed at any length to date in the USO academic literature, although noted elsewhere e.g. the 'living dead' companies of Ruhnka *et al*. (1992). Twilight USOs are designated as USOs that have not been removed but have effectively ceased any significant level of activity. Where the USO has received external funding, a significant time must have elapsed since the last round of funding for the company to be designated as a twilight USO. While there is some form of judgment necessary to designate a USO as a twilight USO, careful analysis of its financial records generally gives a reasonable level of assurance that the designation is a correct one. A twilight company is clearly using up its residual resources to meet its running overhead costs rather than attempting to develop its technology further.

Figure 7.9 below shows the aggregate twilight USO rate for each university of as a percentage of its total population of USOs. As above, the metric does not make any allowance for time effects i.e. newer USOs are less likely to be have had time to fall into the twilight category.



Analysis

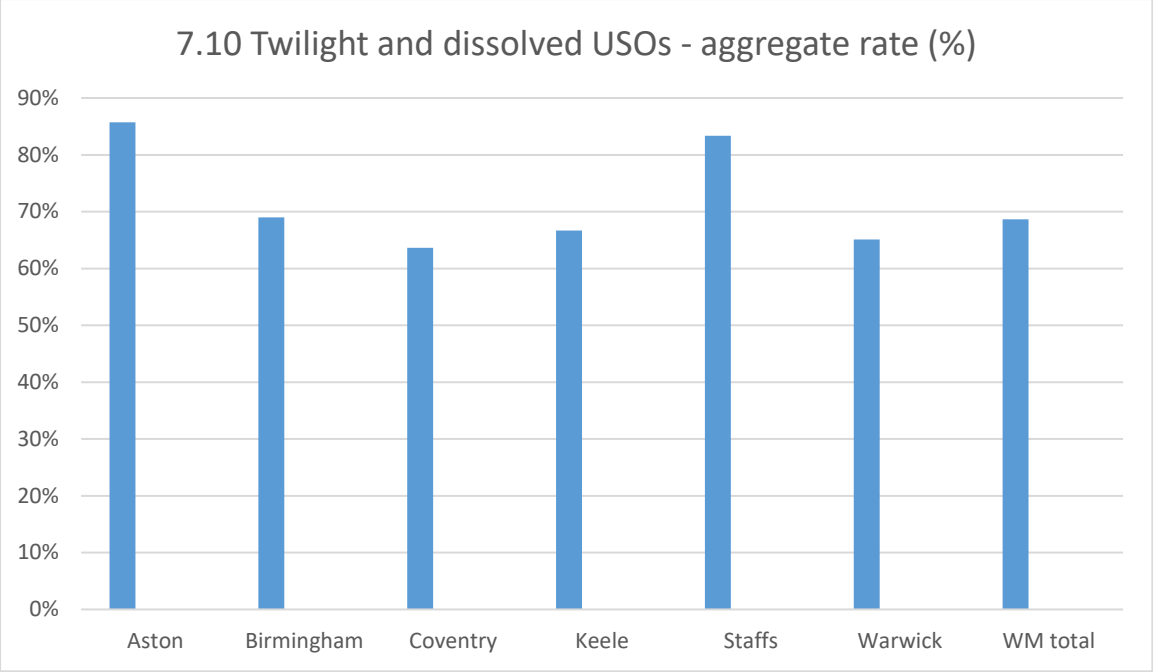
The data shows a reasonably consistent rate of twilight USO formation for the universities across the region of between 20% and 30%. This consistency is of interest because, as noted above, no allowance is made for the age of the USOs in question. In addition, the policy of universities towards USO formation has already been noted to be different, and this would be, on first principles, likely to be the case also for the identification and the management of twilight USOs.

Staffs is an outlier from this consistency with a rate of twilight formation of 50%, although this is manifested on a low number of USOs created (only six in total). A high rate may be indicative of a desire by a university or TTO not to strike off companies for fear of 'losing face' and preferring to keep them running (de Cleyn, 2011). This may be an example of goal incongruence for these USOs that attracted external funding between the TTO and the funder, where the funder may be keener to cut its losses in its poor investment and cease the USO's operations more quickly. The existence of this reasonably significant level of twilight USOs may lead to the conclusion that survival is actually a poor performance metric for USOs. A higher rate of twilight USOs may also possibly be observed when a university secures little external funding for its USOs, as such third parties may on first principles be less concerned about striking a company off where it is clear that the underlying technology is not going to reach any reasonable level of commerciality.

7.2.6 Aggregate Rate – twilight and dissolved USOs

One of the most important characteristics of twilight USOs is that they contribute towards providing a much fuller and more accurate picture of the true failure and survival rates of USOs. Previous studies in the academic literature have claimed that USOs have significantly higher survival rates than other start-up companies and produce a range of reasons attempting to explain this e.g. Zhang (2009).

By combining the aggregate failure rates of twilight and failed USOs, a clearer picture is obtained as to the true failure rate of USOs, and this is displayed in Figure 7.10 below. Comparison with other academic studies will be undertaken at a later stage in Chapter 8.



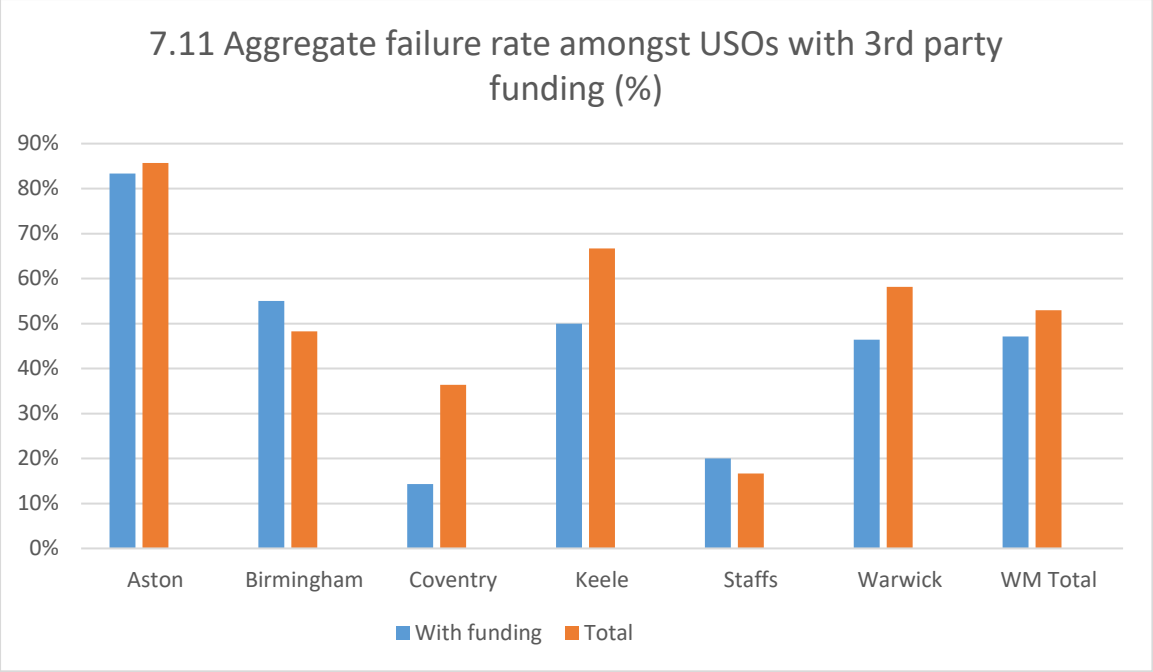
Analysis

The data shows a reasonably consistent range of twilight and dissolved USOs for the universities across the region of between 60% and 70%. This consistency is of interest because, as noted above, no allowance is made for the age of the USOs in question, or their quality, which signalling theory would predict to be linked, in that stronger research universities would produce longer-living USOs (Ziedonis, 2007). In addition, the policy of universities towards USO formation has already been noted to be different. These numbers are significantly higher than those obtained in previous USO academic studies and questions the long-held view that USOs survive longer than other start-up companies; this observation is considered in more depth below.

Aston and Staffs are outliers with total failure rates in excess of 80%. Aston's result is affected by the small number of USOs and the significant age of some of them, being generated well before the more recent increase in overall population as previously noted. Staffs' results are impacted by low total numbers of USOs generated.

7.2.7 Externally-funded failures

USOs that attract external funding might be considered to have a lower rate of failure than the total population for a university given that the funders would perform their own due diligence to identify promising USOs in which to invest their money. Such findings have been noted in the literature e.g. Shane and Stuart (2002), Nerkar and Shane (2003) as discussed in Chapter 3, as well as from the wider VC literature e.g. Manigart *et al*. (2002). Figure 7.11 below compares, for each university in the region, the total failure rate (dissolved USOs plus twilight USOs) amongst companies with external third party funding against the total failure rate for all USOs from the university.



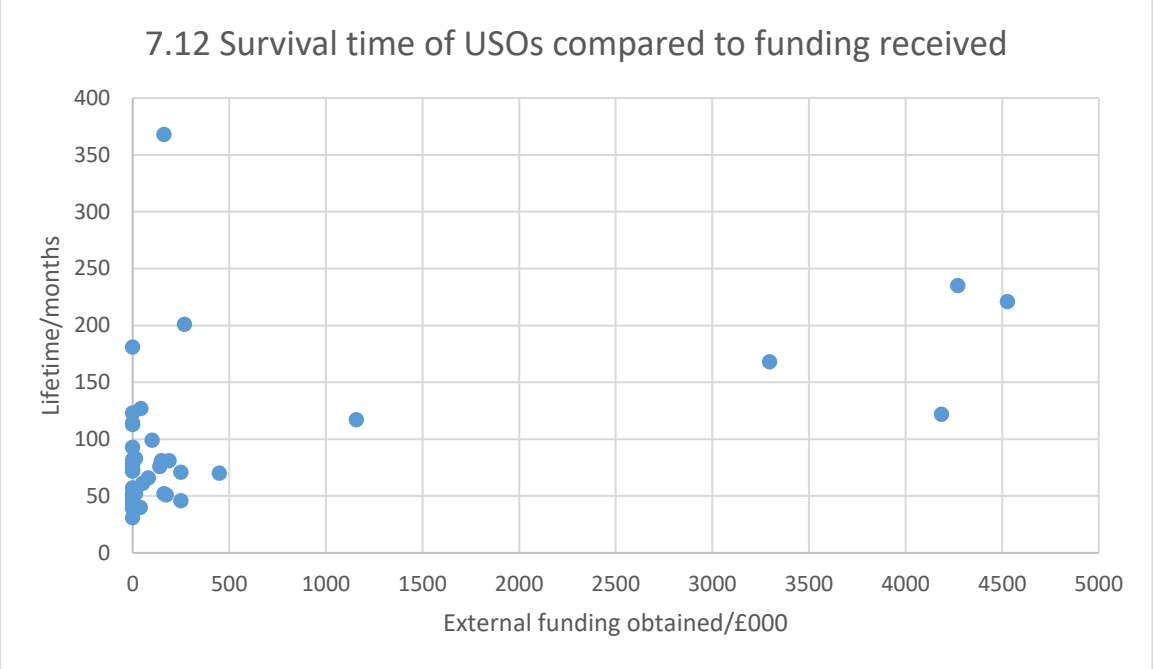
Analysis

In general, the failure rates amongst USOs that obtained external third party funding are lower than those of the total population, as demonstrated by the overall WM universities figures. This gives some confidence to be drawn from the due diligence carried out by the funders and gives some support to previous studies e.g. Manigart *et al*. (2002), although the difference is not particularly large. A notable exception is Birmingham where the order is reversed i.e. third party investors into Birmingham's USOs performed worse than a random selection in spotting companies likely to survive.

This performance metric acts as an interesting crossover between USO survival and third party investment. In some regards it says more about the ability of the investor rather than the USO, but it also gives an interesting indication that USOs as a class of investment are not particularly easy to predict in terms of which will succeed. The findings are in line with signalling theory which would expect USOs sending out strong signals to attract funding and hence survive for longer.

7.2.8. Survival time compared to funding

Figure 7.12 below shows, for all universities across the West Midlands region, the relationship between the lifetime of each USO that failed, and the external funding that it obtained.



Analysis

In general, for the sample of USOs under investigation, companies that obtain more funding survive for longer. This finding is in line with expectations, which would propose that USOs with more financial resources will survive longer as they will be able to meet their expenses incurred in attempting to commercialise their technology for longer, and in line with findings of earlier studies e.g. Shane and Stuart (2002), Nerkar and Shane (2003).

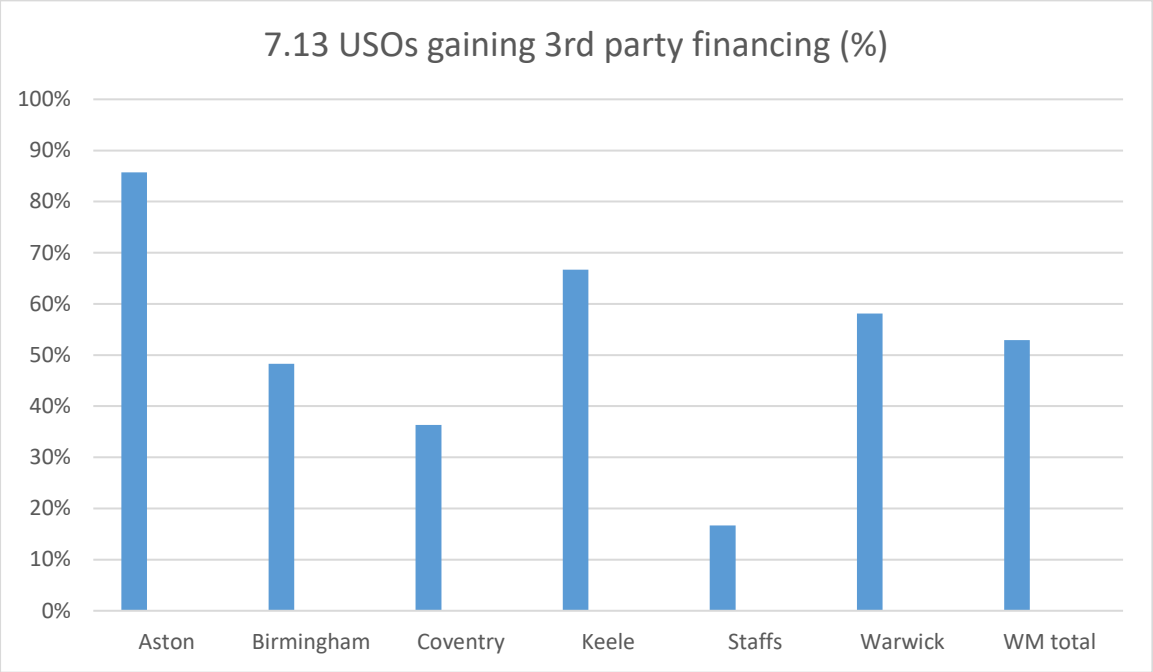
It should be noted, however, that the majority of USOs in the sample obtained very little external funding. In addition, a number of USOs survived for a long time without any or very little external funding, presumably because their technology could be commercialised at an early stage and generate sufficient income to enable the company to survive. The above sample is a small one, so any observations must be made with care, and the relationship noted above is unlikely to be straightforward, in line with Manigart *et al*. (2002).

7.3. External Investment into USOs

The following section considers the second major performance metric of the study, namely the ability of the USO to attract external third party funding. Lambert (2003) and other authors have highlighted the obtaining of third party financing as a strong signal indicating a successful USO, and the fact that UK USOs have a poor record in attracting such finance compared to the US. Both of the key theoretical frameworks described in Chapter 3 will all have a part to play in interpreting the results of this section. Signalling theory postulates that the possession of resources such as attractive technology will send strong positive signals from the USO to the potential investor, and has been used before in the literature e.g. Mueller (2010). Agency theory can be used to comment on the relationship between potential funder and TTO to the extent that this is in line with the observed financial performance data of the USO (Arthurs and Busenitz, 2003).

7.3.1 Rate of attracting funding

Figure 7.13 below shows the percentage of USOs at each university that were able to attract external third party funding, which has previously been considered as a proxy metric for success for a USO.



Analysis

The figure above shows a wide degree of variation across universities and TTOs in the attraction of external funding by their USOs, in line with prior studies e.g. Wright *et al*. (2006). From an overall perspective, this is a different result from the survival results discussed above, where results were often consistent across the universities in the region. This may therefore be a more accurate reflection of a proxy for success of the USO or university as a whole. As a result, it is worth considering the results for each university.

Birmingham and Warwick, as Russell Group members, are responsible for generating about 70% of the region's USOs by number and unsurprisingly show levels of attracting finance close to the mean for the region of 53%. Given the numbers of USOs generated by these two universities, the work required to obtain such a significant number of investments requires the construction of a university-led infrastructure of significant scale, in the shape of a TTO and associated functions, to accomplish this. Signalling theory would support the observation that such research-focussed universities would attract funding for significant numbers of their USOs, which in turn would attract other investors, forming a virtuous circle. However, it is noticeable that their rate of attracting funding is lower than that of Aston, suggesting that some of the larger number of USOs were not attractive to investors, and highlighting that the relationship between university research strength and USO funding is not a straightforward one.

Of the Plate Glass universities, Aston shows a particularly high rate of attracting finance of 86%, well in excess of the regional average, which ties in with its observed philosophy of forming relatively few

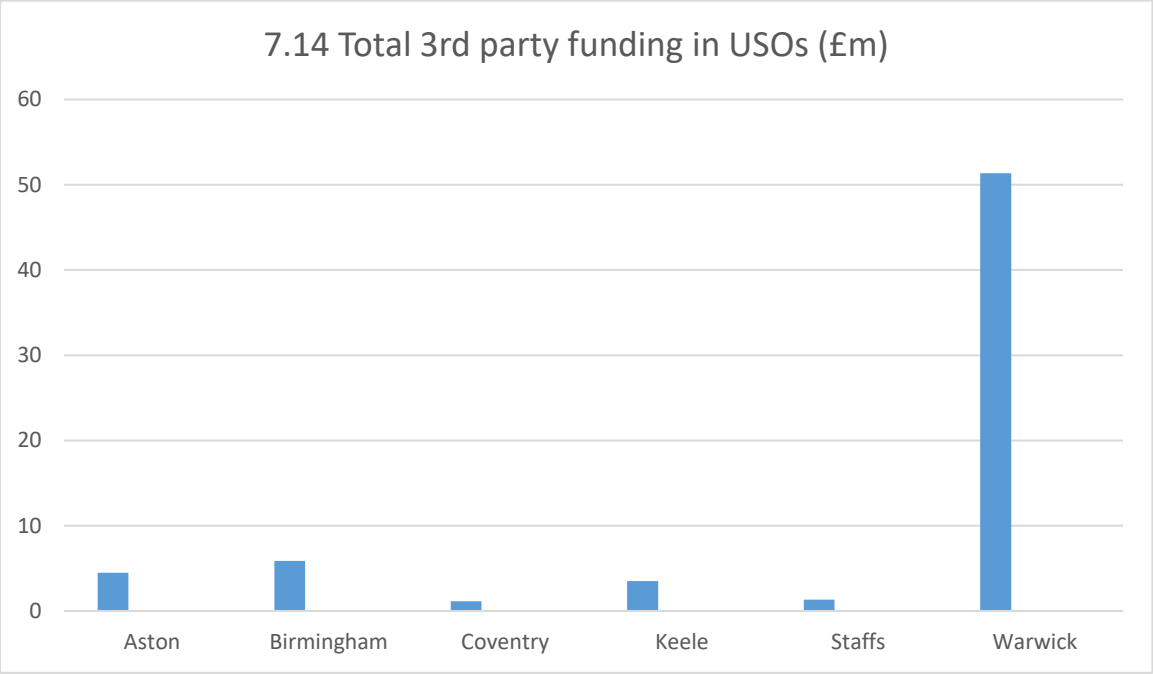
USOs that own technology that is potentially commercialisable and hence attractive to potential investors. As already noted, Aston has a heritage of teaching and research in science and technology, although not a Russell Group member, and signalling theory would agree that such a heritage could lead to a competitive advantage in discovering valuable technologies. Keele also has a high rate of attracting finance at 67%, so these findings are not in line with signalling theory purely considering the research strength of the parent university, but other factors are clearly present, such as sectoral differences e.g. some USOs are more capital-intensive.

Amongst the Post-92 universities, Coventry has a lower rate of attracting finance than the average at 36% and Staffs significantly lower at 17%. This is in line with signalling theory, although the numbers of USOs involved with these institutions is small and may lead to distorted results.

Within the context of the agency theory framework, this range in success across the region's TTOs in securing funding is of interest. Universities with a high rate of attracting funding would appear to have very limited agency problems, with potential investors having confidence in the underlying quality of the USO's technology and its ability to be commercialised. Universities with low rates of funding would appear to have greater agency problems with lack of confidence from potential investors.

7.3.2 Amounts of Funding raised

Figure 7.14 below shows the total amount of third party external funding received by each university for its USOs. As noted in the previous chapter, USOs attract funding from a number of third parties including the regional University Challenge Fund (Mercia Fund), other private equity or venture capitalists, limited companies and individual investors.



Analysis

The graph clearly demonstrates that Warwick has attracted significantly more external third party funding in absolute terms than all the other universities combined. The scale of the difference cannot be explained simply by the fact that Warwick has generated the most USOs in the region (43

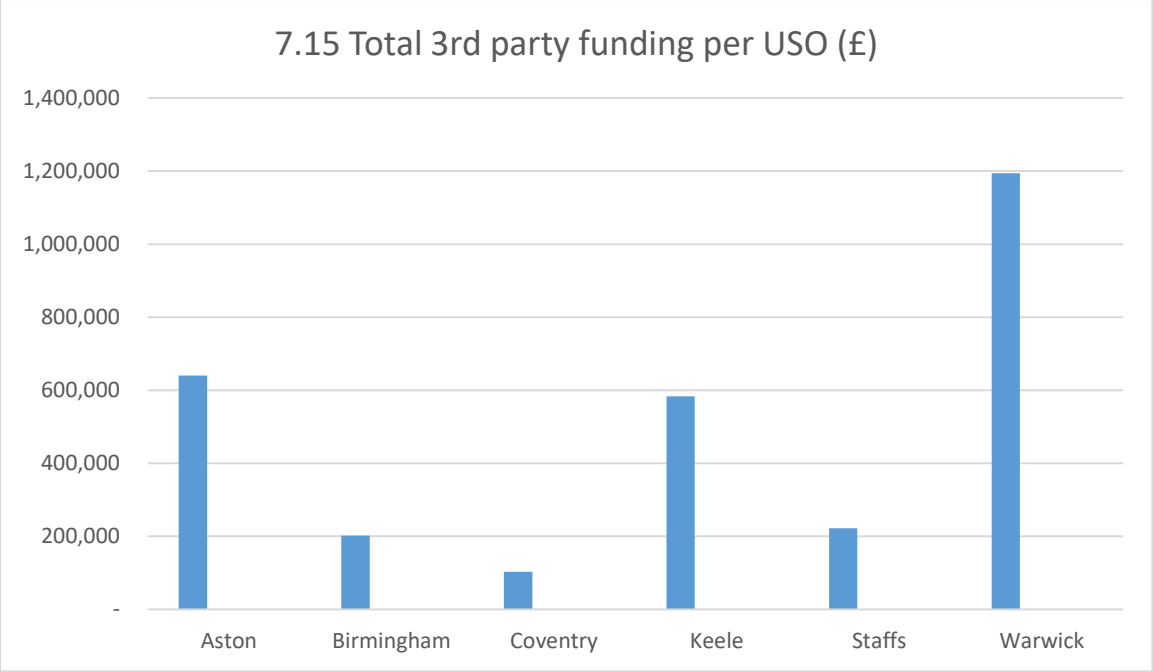
out of 102). Possible explanations are that Warwick USOs are extremely successful based on superior underlying technology and investors are willing to invest large sums of money to obtain potentially significant future financial benefits, or alternatively that Warwick has a vastly superior infrastructure including its TTO for attracting investors and providing them with the information they require. This will be examined later in the chapter when the success of USOs in terms of successful exits is examined. In addition, there is likely to be a cumulative effect whatever the explanation in that apparent success attracts success i.e. if one investor puts a significant amount of funding into a Warwick USO, other investors will notice and be more attracted to invest in the next available USO from the university, which would be in line with the predictions of signalling theory.

It is clear from the large number of USOs generated that Warwick has significant resource in place to attract funding which will include wide networks with potential investors. This is exactly in line with agency theory which predicts multiple future interactions once TTO and external financier have established a basis of trust and overcome potential problems such as information asymmetry, as discussed in Chapter 3. However, the low amounts of funding obtained by other universities, particularly Birmingham, casts some doubt on this interpretations, should the number of USOs generated by a university be a valid proxy for its enthusiasm and desire to obtain funding for its underlying research, such a significant discrepancy between the funding obtained by Warwick and the other universities would not be expected. Clearly other factors are at stake such as pre-entry experience of the USO (Curran *et al*., 2016), quality of the underlying technology and the identity and risk appetite of investors.

Signalling theory based on signals sent by the research strength of the university is less helpful here in trying to interpret the results. While the amount of funding obtained does follow the university's research strength in terms of ranking i.e. Russell Group obtains more funding than Plate Glass, which in turn outperforms Post-92, the magnitude of Warwick's success compared to the other universities, especially its fellow Russell Group member UoB, clearly demonstrates that other factors are involved.

7.3.3 Funding obtained per USO funded

To allow for the range in numbers of USOs formed by each university in the region, Figure 7.15 below helps to contribute to a more accurate picture as it shows for each university the amount of external third party funding obtained per USO generated.



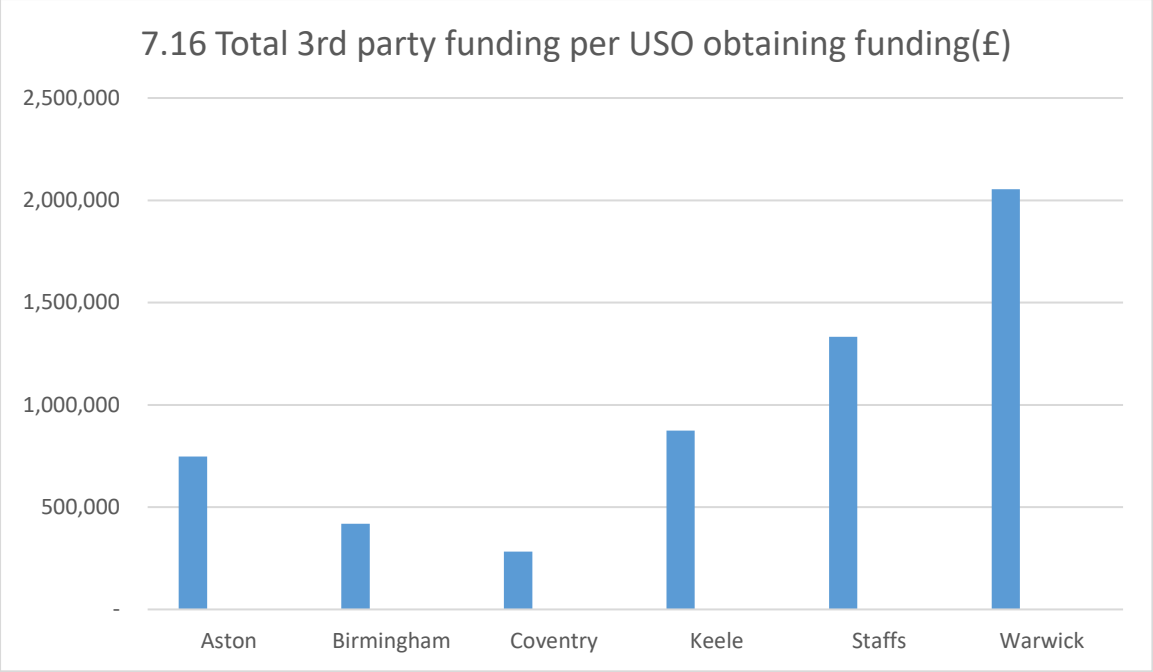
Analysis

Warwick is still significantly ahead of the other universities in terms of funding received per USO although the difference is not as pronounced as in the previous figure. An interesting feature of this graph is the relatively low amount of funding secured per USO by Birmingham, the second largest generator of USOs in the region intimating that they have pursued quantity rather than quality in terms of generating USOs, a key accusation levelled by Lambert (2003) and others, on the assumption that external third party funding is a good proxy metric for the success of a USO. Again, signalling theory would not predict such a low result for UoB.

Of the Plate Glass universities, Aston and Keele score highly on this metric, again suggesting a policy for these two universities of pursuing a small number of potentially high quality USOs with underlying technologies that are of interest to potential investors compared to other universities in the region. The Post-92 universities show very low levels of funding per USO. Overall, signalling theory is of some value when the research strength of the university is considered as the key signal, but UoB's results show other factors must be at play.

7.3.4 Funding obtained per USO

While Figure 7.15 casts some light on the quality of the USOs generated by a university, a slightly different performance metric is the amount of funding received per USO that obtains funding i.e. ignoring USOs that obtain no funding. Figure 7.16 below shows this amount for each university across the region.



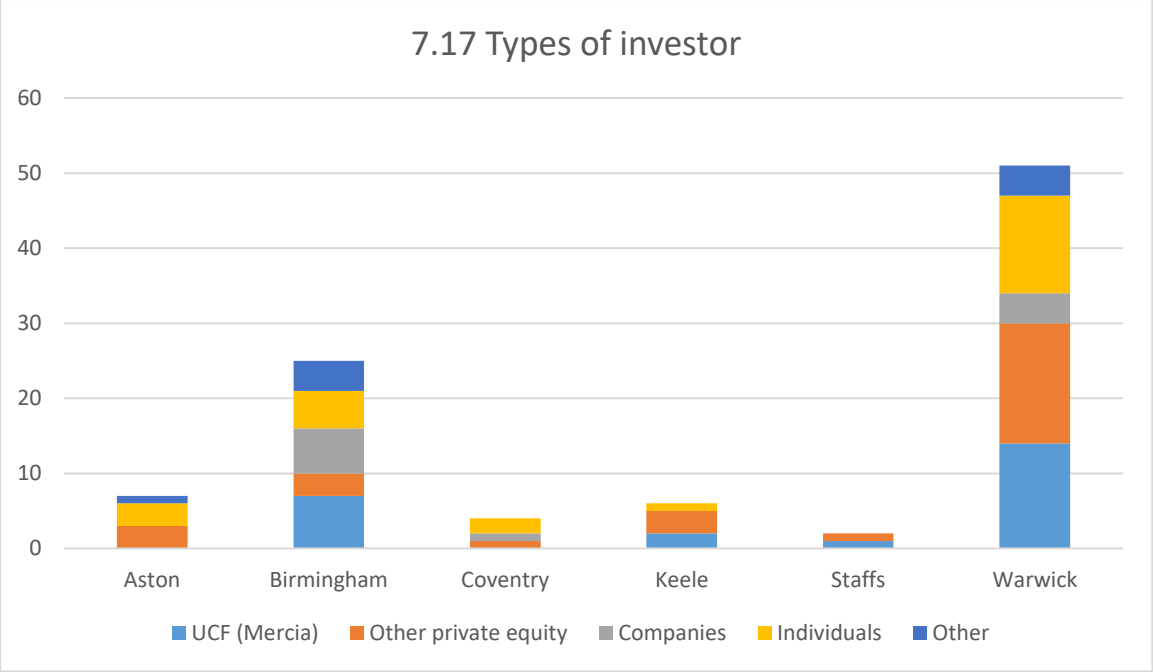
Analysis

The major difference between this metric and that shown in Figure 7.15 is the performance of Staffs which apparently shows an unexpectedly high value of funding actually achieved by its USOs. Further investigation into the detail of the USOs reveals that Staffs only had one out of six USOs that achieved any external funding. This company, Intelligent Orthopaedics Limited, was also a USO of Keele as both universities appear to have contributed towards its development. The company also attracted funding from the Mercia Fund and Catapult Venture Managers, another private equity investor. Although it attracted the investment, the USO was not a success and was designated a twilight USO in this report (it was subsequently dissolved).

Staffs' other USOs attracted no funding at all, so this particular USO which achieved external funding distorts the results, and leads to possible questions as to how much involvement Staffs truly had with its development. The picture under signalling theory is complex; Staffs has a low rate of attracting finance for its USOs, which implies that it lacks suitable networks with potential investors, or research strength of the university, which would be strong signals for investors, but one USO in the shape of Intelligent Orthopaedics Limited had underlying technology which attracted financial resources from third parties, and hence gave a strong signal, distorting the overall picture for the university and highlighting the need to consider a range of performance metrics within the overall metric of attraction of investment.

7.3.5 Types of investor

Figure 7.17 below details, for each university, the number of USOs that obtained external funding from each particular source to examine the spread of funders. Unfortunately it was not possible to obtain further details of the investments such as the amount invested by each party or the number of funding rounds because the data was not consistently available. A number of funding rounds dated back several years, meaning that records were no longer in the public domain, and amounts invested by each investor were often not disclosed, most likely for reasons of confidentiality.



Analysis

Each university obtained external funding for its USOs from a range of sources in line with earlier studies (Shane and Stuart, 2002). In terms of UCF funding, which as mentioned above was a key driver in accelerating the rate of creation of USOs, it is interesting that Aston and Coventry did not receive any funding whereas the Russell Group universities of Birmingham and Warwick, in particular, took full advantage of the government-backed scheme to help fund a number of their USOs. UCFs provided financial resources to universities specifically for the purpose of forming USOs, enabling institutions to access funding for early stage technologies without having to create significant infrastructure to attract other sources of funding. These results are in line with signalling theory in that strong research universities send strong signals to investors, and have greater resource to set up TTO operations.

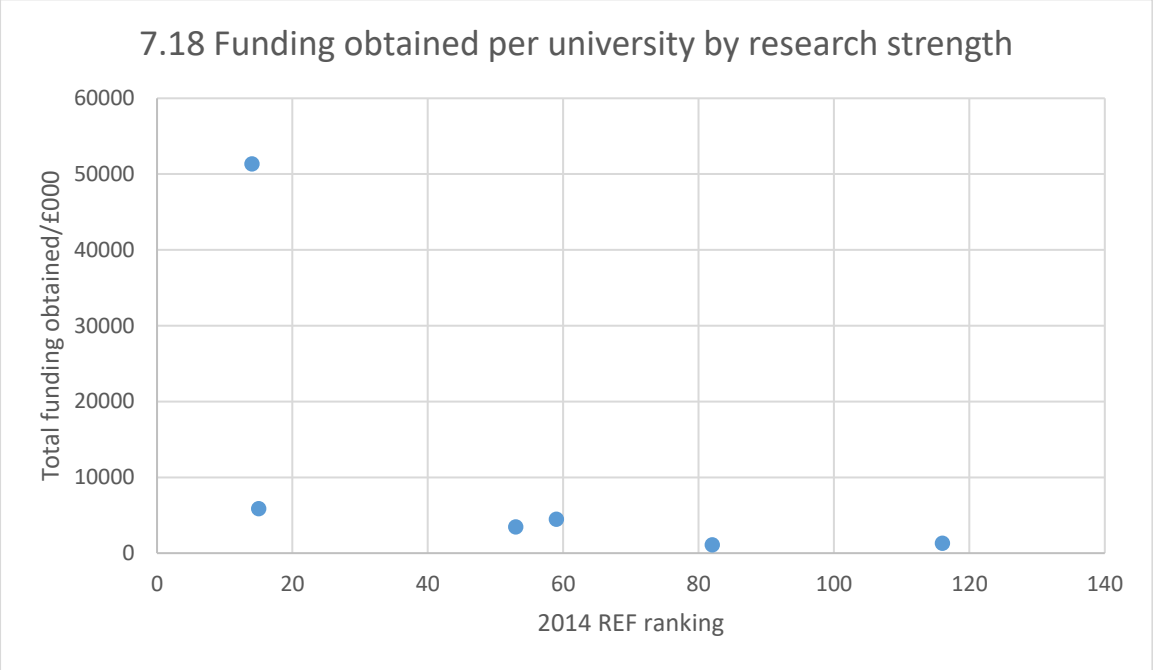
However, it is noticeable that all of the universities did not rely solely on UCF money. All universities were able to attract some other private equity investment into their USOs, showing that each of them must have formed some kind of links with the investment community. Warwick was particularly active in securing investments of this nature, some of which were significant in size and contributed towards the result observed above of a very significant amount of external funding received. Warwick was also notable for obtaining a wide range of different private equity funders, suggesting that as a university it created exceptionally strong social networks with the private equity community and leading to a clear competitive advantage over the region's other universities in this specific aspect, again highlighting the absence of agency problems with potential funders. In line with signalling theory, the existence of other investors (Diamond, 1991) and large numbers of USOs sends strong signals to investors.

Individuals also contributed towards a large number of USOs, making up a significant proportion of the total number of investors at a number of the universities. Investments by companies were not so prevalent, despite the suggestion previously made in the literature that such investments could be beneficial for a successful USO programme for a university. It is likely that the universities found it harder to form worthwhile links with companies rather than the investment community on the basis

that companies may prefer to pursue research independently, or at least have exclusive access to its results. In addition, it may have been more difficult for universities to identify suitable companies to invest in their USOs, given that this would require significant resource to achieve, especially starting from a low base in respect of infrastructure.

7.3.6 Funding by research strength of university

In line with the earlier measure of number of USOs by research strength, Figure 7.18 below shows the total funding obtained by a university by research strength using the 2014 REF rankings. Only universities that generated USOs are considered in this analysis.

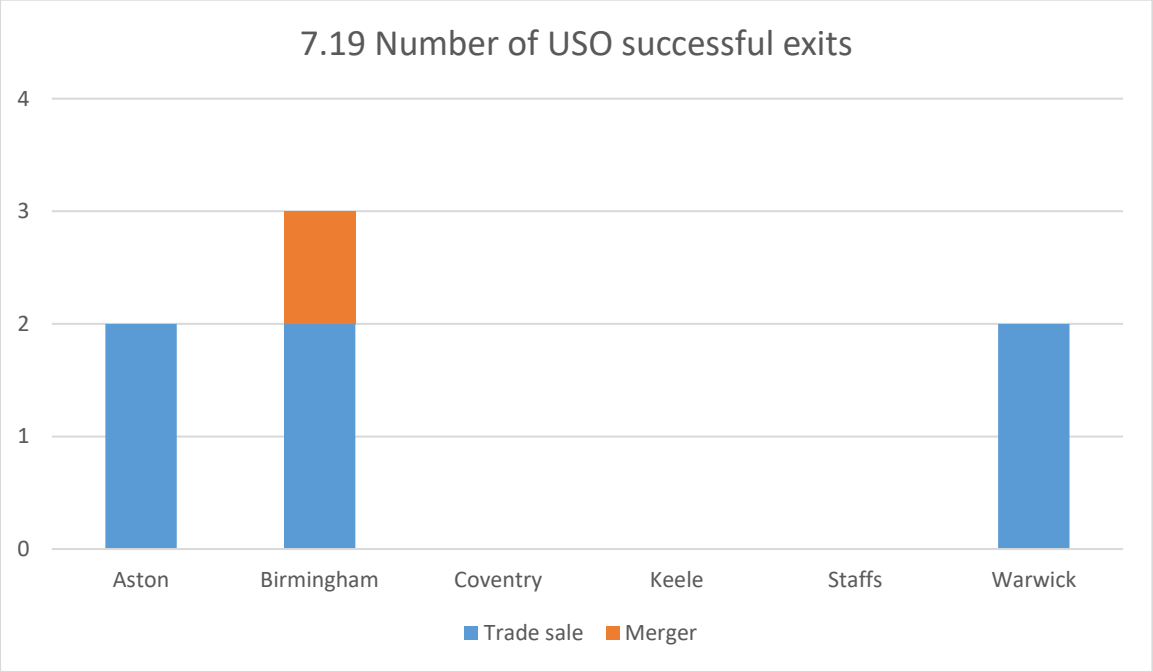


Analysis

The results show a trend towards increased funding obtained with research strength of the university, although the correlation is distorted by the significant funding obtained by Warwick, although this is not in line with previous studies which found no correlation e.g. Tornatzky *et al*. (1997), Rodeiro Pazos *et al*. (2012). On first principles this is in line with the theoretical frameworks of this study; under agency theory external funders will be attracted and potential agency problems overcome as the TTO demonstrates the quality of the USOs' underlying technology and their desire to commercialise it, leading to goal alignment with the potential funder and trust being built. Signalling theory is also of relevance as high quality technology developed by a strong research university will send positive signals to potential investors. However, the previous results and analyses have clearly demonstrated that research strength of a university is not by itself the sole factor behind a USO's success, so the above graph must be treated with caution, and more data from other universities should be obtained and analysed.

7.4 Number of exits

The final performance metric is that of successful exits from a USO by its parent university. One of the most important metrics in determining the success or failure of a programme of USO creation for a university is the amount of money for which the university can realise its investment in a controlled exit such as a placement of shares, merger or trade sale (Bonardo *et al.*, 2011). Figure 7.19 below shows the occurrence of such events for the universities across the region.



Analysis

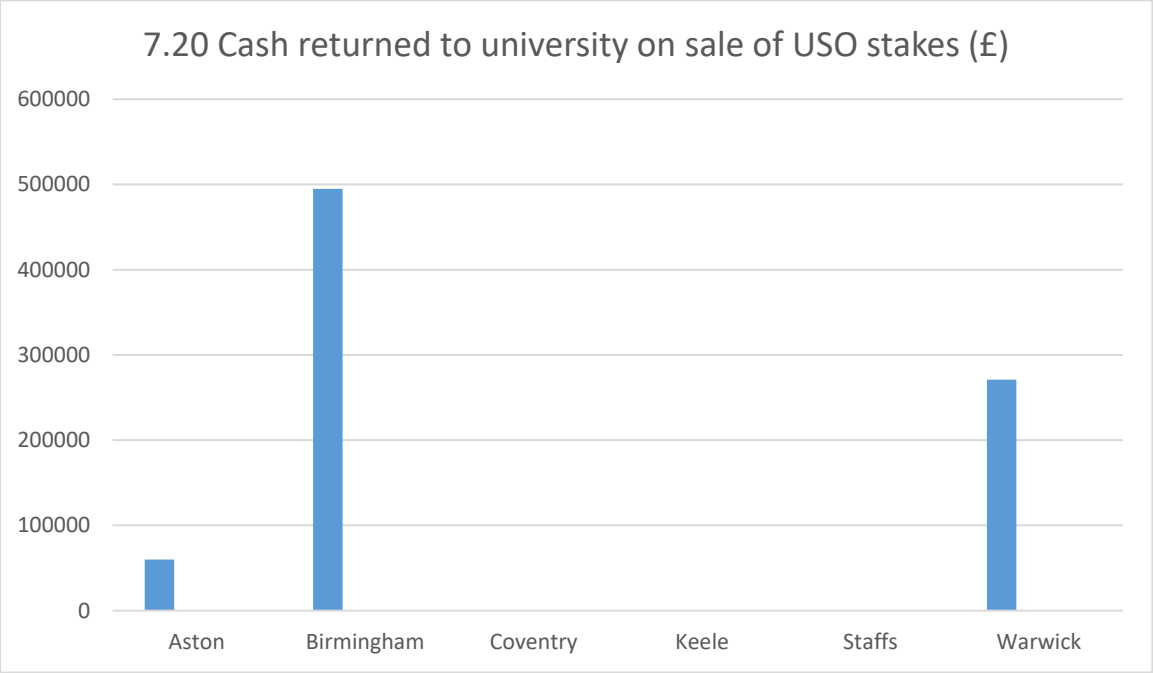
Figure 7.19 demonstrates that across the whole West Midlands region, and despite the significant amount of activity in creating USOs, the financial impact for the sponsoring universities has not been positive. Despite the large numbers of USOs created, the number of successful exits made from USOs is extremely low. It is particularly noticeable that no USO from the West Midlands has ever achieved a stock market listing in any form, a particularly unfavourable comparison with the US (Zhang, 2009), and even with other UK universities such as Oxford and Cambridge (Holi *et al*., 2007).

Amongst the Post-92 and Plate Glass universities, Coventry, Keele and Staffs have not made any successful exits at all from their USOs, showing that their programmes have had no financial success to date. The more established three universities of Aston, Birmingham and Warwick have had slightly more success, but with some wide variations. Aston continues to reinforce the earlier themes discussed of a small number of USOs that contain commercialisable technologies, and which have ultimately here lead to successful exits. Of the Russell Group members Warwick, despite creating large numbers of USOs and achieving a very significant amount of external investment into them, has fared no better than Aston in taking them to an exit. Birmingham falls within the two with a very similar exit record on a number of USOs that falls between the other two universities.

These results are difficult to explain using the theoretical frameworks selected. An exit is essentially a special form of external investment, so it would be expected that of the Russell Group members, Warwick would show significantly more exits than any of the other universities within the region given that it attracted far more external investment, which was at least partly attributable to its research strength. Clearly this is not the case, and the results suggest that the quality of Warwick's technology that it attempted to commercialise via its USOs was, in fact, not strong. The only clear conclusion is that information asymmetry remains a significant factor for investors, even where a university has a strong research pedigree. There is a slight trend in that the three strongest research universities were the only ones to obtain any exits, but this does not explain the absolute level of exits seen across the region.

7.4.1 Financial benefit to universities

As noted above, the number of successful exits from a financial perspective for universities from USOs throughout the region is extremely low. Figure 7.20 below shows the actual cash received on exit by the universities through the disposal of their equity stakes.



Analysis

In terms of exits, the most successful university in the region is Birmingham, which was largely based on the sale of its stake in one USO; Entice Technology Limited. As noted in Chapter 5, this USO did not secure any external financing, so it is clear that the underlying technology was the key resource behind the ultimate financial success of the company. It is fair to conclude that this company was the only financially successful USO in the whole West Midlands region during the observed period of 30 years. As noted in the previous chapter, Warwick's actual returns may have been significantly less than shown above.

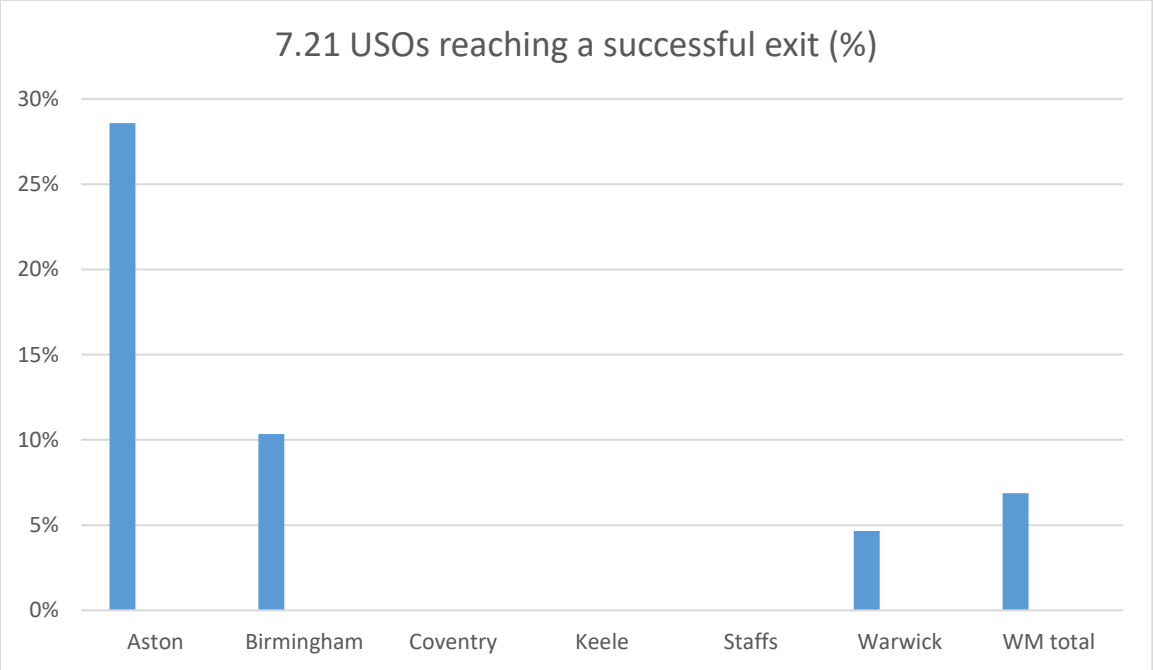
Again, the figure highlights the lack of a successful financial return to the region's universities as a result of their USO programmes, despite significant numbers of USOs being created and significant sums of money being raised to invest in them. While there are other factors than purely financial to

assess whether a programme has been a success, the failure to match the apparently significant sums raised by US USOs and some USOs from other UK universities must be a major disappointment to those responsible at these universities and backs up previous studies sceptical of return from USOs e.g. Harrison and Leitch (2010). It is unlikely that the sums shown above even covered the running costs of the various TTO operations at each of the university, and certainly did not generate any profit over and above its fixed and variable costs, which back up the findings of previous studies e.g. Hague and Oakley (2000), Hughes (2007), Siegel and Wright (2015).

As discussed, this result is difficult to assess within either of the theoretical frameworks chosen as the only financially successful USO did not obtain any external funding. Both frameworks would have assumed that USOs obtaining the most funding are more likely to be successful and hence these results are not in line with theory.

7.4.2. Percentage of successful exits

Following on from Figure 7.20, the figure below shows the percentage of USOs created at each university in the region to provide their parent institution with a successful exit. This important metric gives some guidance as to the success of the university in identifying and then creating successful USOs.



Analysis

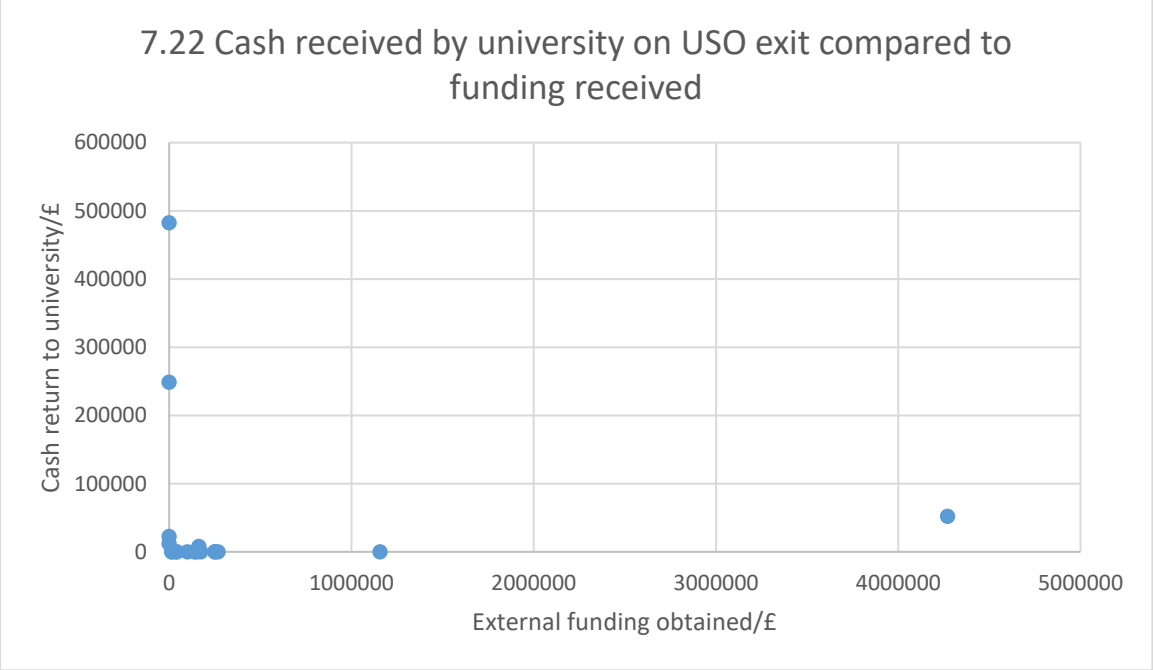
Under this metric, Aston shows a rate of success significantly higher than any of the other universities. This finding again reinforces findings from earlier metrics which have indicated a policy for this university of creating only a small number of high quality USOs.

Of the Russell Group universities, Birmingham and Warwick have a low rate of success in terms of their USOs reaching a successful exit. This finding is in interesting contrast to their success in attracting third party external funding, as already discussed, especially in the case of Warwick, and their activity in generating significant numbers of USOs. It would appear that both universities may be exhibiting the behaviour identified by Lambert (2003) of trying to focus on quantity rather than

quality of USOs, and simply using the available funding in the form of the UCF to fund their programmes.

7.4.3. Cash returns to university compared to funding

Figure 7.22 below shows the relationship between the cash returned to the university by USO compared to the funding it received. Only USOs that exited or failed during the period under review were considered.



Analysis

The above results further demonstrate that, to date, universities in the West Midlands have made very little financial return on their USOs. In addition, there is little correlation at the USO level between the amount of money it receives and the return to the university, as the best returns have occurred where there was no or little external funding, where the technology was clearly ready to be commercialised at an early date. This is not in line with signalling theory, which would predict that USOs with greater external financial resources will show superior performance including returns to the parent university, as the company will have been able to give out strong signals, probably including the strength of their technology, to allow potential investors to reduce their fear of information asymmetry and uncertainty when deciding to invest. It is also not in line with previous studies e.g. Shane and Stuart (2002) which would predict better funded companies to be more likely to have a successful IPO. It should be noted that the sample is relatively small, and that improved results will be obtained as the USOs within this study come to the end of their lifetimes.

7.5 Conclusion – West Midlands region

The above results and discussions provide an interesting insight into the ability of the chosen theoretical frameworks of this work to rationalise and explain the financial performance data of the region's USOs. While some results are in line with the expectations of the frameworks, others are not and demonstrate the complexity in attempting to explain the data, and the need to consider wider data sets and more explanatory factors. The classification of the universities into three different groups, based significantly upon their research strengths, also serves to provide a further dimension to the analysis.

In terms of the numbers and activities of the USOs generated, universities with a strong research pedigree generated the most USOs in line with the theoretical frameworks, with the Russell Group universities dominant in the region, although this finding is not in line with some earlier studies e.g. Tornatzky *et al*. (1997). However, even at this stage it is clear that universities may have different policies with regard to USO formation, with the Plate Glass university of Aston, with good research credentials, creating a low number of USOs. The formation of USOs in the period under observation can be seen to be heavily dependent upon the UCF funding provided by the UK government. The principal activity of the USOs is dominated by life sciences and IT, in line with previous studies.

The data relating to survival of USOs is more difficult to rationalise and leads to a tentative conclusion that this is not a useful performance metric, despite earlier opinions noted in Chapter 3 e.g. Library House (2008). In line with previous studies, USOs survive for longer than other start-up companies e.g. Zhang (2009), and twilight USOs are also shown to be significant, backing up the findings of de Cleyn (2011), who identified that many European universities adopted policies to keep underperforming USOs alive; this therefore indicates that survival times say little about the underlying USO quality (Agarwal *et al*., 2004). However, a number of the survival measures show a degree of consistency across the different kinds of university, which would not be expected under the theoretical frameworks, as USOs from stronger research universities would be expected to survive for longer (Conceicao and Faria, 2016). In line with previous studies e.g. Shane and Stuart (2002), and the theoretical frameworks, it is found that USOs with external funding tend to survive for longer.

The data on external funding appears to be in line with prior studies e.g. Shane (2004) and the theoretical frameworks in that the total funding obtained by a university is positively correlated to its research strength, although the Russell Group member Warwick shows an exceptionally high level of funding obtained. However, at a more granular level, by reviewing the amount obtained per USO the picture is more mixed, with both the Plate Glass universities of Aston and Keele outperforming Russell Group Birmingham, implying a more focussed approach in creating USOs, and showing clearly that other factors than the research strength of the parent university are at stake. These include the fact that certain sectors such as life sciences are more capital-intensive than others e.g. IT and consultancy, some of which can essentially be self-supporting.

Finally, the data on exits demonstrates the inability of all universities across the region to generate financially successful exits. This general lack of success is difficult to explain using the theoretical frameworks, particularly given the success in attracting funding, implying attractive technologies were created, and is not in line previous studies e.g. Shane and Stuart (2002). In fact, the only financially successful exit was by a USO that had no external funding, demonstrating a lack of commercialisable technology generated across the region.

The next chapter will attempt to extend this analysis to compare with results from other studies in the literature. This is an important step, as the number of USOs in the current study is relatively small, and conclusions must therefore be drawn with care. Overall, however, the West Midlands region has shown results that can sometimes, but not always, be explained by the theoretical frameworks, and are not always in line with prior studies.

8. Comparison of results with existing studies

8.1 Introduction

Following on from the previous chapter, which sought to compare and contrast the financial performance results obtained by USOs throughout the West Midlands region, the current chapter will undertake a similar comparison but against results from those studies existing in the academic literature in line with the further research question in Chapter 4. These will include results for USO survival, attraction of external investment and whether the parent university successfully exited its investment. The comparisons will also be evaluated within the chosen theoretical frameworks of signalling and agency theories to assess whether the results are consistent with those predicted under the frameworks, in particular the research strength of the parent university which is predicted under both frameworks to lead to greater external investment and successful exits. However, as noted in the introduction to Chapter 7, other explanations will need to be considered, and the predictions of the frameworks may be too simplistic.

As already noted, the relevant USO financial performance literature is small but growing, and includes studies of USOs in both the UK and a number of different countries (Fini *et al*., 2016). However, the proportion of the literature that focusses on the performance metrics of this work is still a small one, and the number of such studies and comparisons that can be drawn are limited.

8.2 USO survival studies

A number of early USO financial performance studies in the literature collected data on the aggregate survival rates of their USO sample. The tables below combine USO survival data from Oskarsson and Schläpfer (2008), other studies in the literature on a country or university level and the universities of the West Midlands from the current work. The majority of survival studies in the literature are not of recent provenance; more recent studies have focussed on external investment of the metrics under consideration in this work.

Country	Survival rate (%)	Period	Years	Sample size	Source
USA	68	1980-2000	21	3376	Shane (2004)
Canada	73	1995-2003	9	301	Clayman and Holbrook (2006)
Hong Kong (timed rate after 5 years)	79	1997-2004	8	56	Leung and Mathews (2006)
Netherlands	83	1984-1992	9	92	Shane (2004)
France	84	1984-1987	4	100	Mustar (1997)
Sweden	87	1960-1993	34	30	Shane (2004)
Northern Ireland	94	1984-1995	12	17	Shane (2004)
Sweden (timed rate after 2 years)	73	1994-2002	9	528	Wennberg *et al* (2011)

Sweden (timed rate after 5 years)	53	1994-2002	9	528	Wennberg *et al* (2011)
USA	94	1991-2001	11	655	Zhang (2009)
UK	58	1983-2013	31	102	Current work
UK (including twilight USOs)	31	1983-2013	31	102	Current work

Table 8.1: USO Survival data by country (author-derived data)

University	**Survival rate (%)**	**Period**	**Years**	**Sample size**	**Source**
USA – MIT	80	1980-1996	17	134	Shane (2004)
Oxford	90	1950-2004	55	64	Lawton Smith and Ho (2006)
London	92 82	3 year timed 5 year timed		202	Lawton Smith *et al*. (2014)
ETH Zurich	88	1998-2007	10	130	Oskarsson and Schläpfer (2008)
Aston	14	1983-2013	31	7	Current work
Birmingham	31	1983-2013	31	29	Current work
Coventry	36	1983-2013	31	11	Current work
Keele	33	1983-2013	31	6	Current work
Staffs	17	1983-2013	31	6	Current work
Warwick	35	1983-2013	31	43	Current work

Table 8.2: USO Survival data by University (author-derived data)

Analysis

A number of interesting discussion points arise from the above tables. It is clearly demonstrated that the survival rates of USOs observed in the current study are significantly lower than all of those observed in previous academic studies. Table 8.1 shows that the current study's survival rates for the West Midlands region are lower than all country studies even when only companies that have been removed from Companies' House (or the host country's equivalent) are considered (which is the criterion used by all the other studies). In addition, survival rates are significantly lower when twilight USOs are also considered. The only exception to this finding relates to the study of Wennberg *et al.* (2011), and here the results are not directly comparable as the failure rate in this study refers to the timed failure rate rather than the aggregate. It should also be noted that the duration of the study of Wennberg *et al.* (2011) was much shorter that the current work, which may hinder comparisons.

It should be noted that the difference in the period lengths under study does not invalidate comparisons between studies; as discussed above in the current study, 65% of USOs that failed had done so by the seventh year of their existence. It is particularly interesting that Oskarsson and Schläpfer (2008) completely independently for a dataset from a Swiss university also identified seven years as a key milestone after which failure rates start to level off. However, the length of a period of study should always be borne in mind, especially when seeking to draw comparisons with other

studies. A number of studies in Table 8.1 look at a time period of eight to nine years, which is quite short, and given that the failure rates are aggregate the key seven year barrier will not have been reached for the majority of USOs, so results may not be fully comparable with those from longer studies such as the current work. Similarly, certain studies have a long period length of study, but as already discussed, USOs were not created in significant numbers in any country including the US until relatively recent times, so the studies are likely to be weighted in terms of population towards the end of the period of study.

Table 8.2, which shows the total survival rate for USOs from the current study by university i.e. including twilight USOs, also shows a similar picture i.e. a much lower rate of survival when comparing the current work against existing works covering a single university. It should be noted that the ETH Zurich figures (Oskarsson and Schläpfer, 2008) also include twilight USOs whereas the MIT (Shane, 2004) and Oxford (Lawton Smith and Ho, 2006) figures do not i.e. only companies dissolved at Companies' House and its US equivalent are included.

The key question here is why the survival figures in the current work are so much lower than those shown in the majority of previous academic studies. The inclusion of twilight USOs clearly has an impact in significantly reducing measured survival rates, while providing a much clearer picture of the state of a university's USOs, but even if these are ignored the overall survival rate is still significantly lower. It is possible that the universities in this study have a very different policy to those in previous studies in that they dissolve their USOs more quickly, or even produce fewer USOs of sufficient quality to survive. This latter suggestion would be tentatively in line with signalling theory, in that ETH Zurich, MIT and Oxford are significantly stronger research universities than even the Russell Group members of the West Midlands, which might lead to better quality underlying technology for their USOs, more external finance attracted and hence greater survival times. Management quality is another potential signal for investors with more prestigious institutions more likely to be able to attract such individuals to work for their USOs. However, these explanations must be considered with care, as the universities in this study still have plenty of pedigree in teaching and research in science and technology, departments from which most USOs originate, and the comparative academic studies across a whole country are likely to contain a wide range of universities, so it unlikely that the West Midlands region is radically different in these respects. With regard to the potential policy of rapid dissolution of USOs, it is unlikely in any case that the university will be the primary decision-maker in the matter, especially where it only holds a minority equity stake in the USO and external investors are present.

It should also be noted that previous academic studies have attempted to compare their USO survival rates with those of all start-up companies in the same country e.g. Lawton Smith and Ho (2006), Oskarsson and Schläpfer (2008). Although there is some difficulty in obtaining comparable data, the results appear to demonstrate that USOs have a significantly longer life than other start-up companies. This may be a deliberate policy on the part of universities in prolonging the lives of 'living dead' companies, but there may be more fundamental reasons.

While theoretical frameworks may contribute something towards understanding the results, the answer to the query of survival rate differences is perhaps more likely to be connected to the difference in the quality of the dataset being constructed and analysed in this work compared to previous studies. It is noticeable that previous studies have usually relied on records kept by others that may not be complete e.g. many studies will typically approach the university TTO for details of USO formation, and USOs themselves or again the TTO for details of external investments. It is highly likely that such sources omit, or simply miss off through lack of information, details about older USOs in particular. For example, Zhang (2009) only records USOs that actually received venture

capital funding and were maintained on a venture capital database, which displays a strong survivor bias and significantly limits the completeness of the USO population given that many USOs do not receive such funding. Oskarsson and Schläpfer (2008) used questionnaires sent to USOs to record a range of sophisticated performance measures, and there must be a significant risk of individuals at the USO providing incomplete information through a lack of knowledge (if they recently joined the company), lack of understanding of the data being requested or simply lack of time to complete the request adequately. It is noticeable from Chapters 5 and 6 that had only one source of data on USO performance been used in the current work, an incomplete picture would have emerged, and none of the data sets relied on the memory of individuals. In addition, it is often the older USOs, about which there is now little data or accumulated knowledge (Lawton Smith and Ho, 2006), which subsequently failed, and are hence of particular interest in this kind of study. There is therefore a significant danger of survival bias in the data collected by certain studies, a danger already acknowledged in the literature e.g. Shane and Stuart (2002). The high quality of the data set constructed for analysis during this work, involving comparisons and cross-checks between a range of independent, objective sources, is one of the key differences in this work compared to existing studies and fills a significant gap in the current academic literature.

8.3 External investment and exit

The tables below compare data collected from the current work and previous studies, some of which were previously collated by Oskarsson and Schläpfer (2008), concerning the performance metrics of attraction of third party external funding by USOs and successful exits from USOs across a range of universities from different countries, although mostly from the UK. Table 7.3 simply shows the percentage of USOs that attracted external third party funding that were created at each academic institution. Table 7.4 shows the percentage of USOs that achieved a successful exit for its parent through a trade sale or IPO of its shares. In the same format as above, Table 7.5 shows the total amount of external funding secured by a university for all of its USOs, while Table 7.6 shows the amount of funding obtained by USOs that obtained any level of funding i.e. removing the distorting influence for a university of its USOs that did not achieve any external funding.

Oskarsson and Schläpfer's (2008) study on ETH Zurich was only able to obtain data on funding from 82 of its 130 USOs as a result of non-responses to their questionnaire, hence the smaller sample size in Table 7.5, although the authors did not consider that this fact distorted any of their results or conclusions. Data in Table 7.6 for the other UK universities is not complete as the Holi *et al.* (2007) report can no longer be accessed, although enough relevant information was obtained from citations in Oskarsson and Schläpfer (2008) to enable a useful level of comparison with other studies.

University	**Total USOs**	**Number with external funding**	**% with external funding**	**Source**
ETH Zurich 1998 - 2007	130	34	26	Oskarsson and Schläpfer (2008)
10 UK universities 1998 - 2002	172	111	65	Minshall and Wicksteed (2005)

Cambridge, Oxford, Imperial College, University College London	99	71	72	
Edinburgh, Newcastle, Southampton	36	25	69	
Cranfield, Loughborough, Strathclyde	37	15	40	
20 UK universities 2001 - 2006	233	137	59	Holi *et al* (2007)
Cambridge	30	20	67	
Oxford	24	18	75	
Imperial College	29	19	66	
University College London	9	6	67	
Edinburgh	26	15	58	
UK universities 1985 - 2007	123	42	34	Munari and Toschi (2010)
UK universities 1990 - 2007	125	78	62	Mueller (2010)
West Midlands 1983 - 2013	102	54	53	Current work
Aston	7	6	86	
Birmingham	29	14	48	
Coventry	11	4	36	
Keele	6	4	67	
Staffs	6	1	17	
Warwick	43	25	58	

Table 8.3 Percentage of USOs attracting third party financing (author-derived data)

Analysis

Table 8.3 shows a number of features worthy of further discussion. Firstly, ETH Zurich has a materially lower percentage of its USOs obtaining external funding than the equivalent UK universities despite its focus on science and technology teaching and research. This finding was previously noted by Oskarsson and Schläpfer (2008), who reasonably attributed the difference to the existence of UCF funding in the UK, where there was no such equivalent funding available in Switzerland from government specifically designed to create USOs. It is interesting to note that the universities of West Midlands region overall obtained a similar level of USOs obtaining external funding to the UK universities studied by Holi *et al* (2007), Mueller (2010) and Minshall and Wicksteed (2005), in the region of 50-60% of all USOs created, which provides some comfort as to the reasonableness of the findings. The much lower figure obtained by Munari and Toschi (2010) is therefore slightly puzzling although their study only includes funding by venture capitalists, both private and public (including UCFs), so does not appear to include funding by individuals. It may be

that their study suffers from an incomplete data set, as it relies primarily on a single commercial database to identify venture capital funders, and as already noted such databases are often incomplete due to a desire to keep commercially sensitive transactions secret.

It has previously been suggested by a number of studies e.g. Munari and Toschi (2010) that the amount of external third party funding obtained by USOs will be dependent upon the research excellence of the parent university. This is in line with signalling theory, which would predict that strength in research would attract investors, and agency theory, in that trust between investors and strong research universities would be quickly established. It is interesting to note that the universities disclosed separately in the study of Holi *et al.* (2007) constitute some of the elite UK research universities (Cambridge, Oxford and certain of the London universities, sometimes collectively referred to, especially by policy makers, as the 'Golden Triangle'), and those from the West Midlands region in the current study generally show a lower rate of funding achieved for their USOs, as might be expected from universities with a lower standard of excellence, even though two of them are Russell Group members. These results are again strongly comparable with those of Minshall and Wicksteed (2005) showing the Golden Triangle outperforming in terms of funding, which provides comfort over the levels of attraction of funding observed. Of course, measuring research excellence of a university is not a simple task, and previous studies will often use rankings in various surveys carried out by education institutions. While simple to use, this measure is a fairly crude one. Amongst the West Midlands universities, Aston shows an exceptionally high rate of attracting finance as previously discussed, and Warwick is comparable with Edinburgh (another Russell Group member), although lower than the top rank universities of Oxbridge and London. This relatively limited study therefore tentatively shows that there is a connection between research excellence and attraction of funding to a university's USOs.

University	**Total USOs**	**Trade sales**	**% trade sales**	**IPOs**	**% IPOs**	**Source**
ETH Zurich 1998 - 2007	130	8	6.2	1	0.8	Oskarsson and Schläpfer (2008)
US universities	655				7.6	Zhang (2009)
20 UK universities 2001 - 2006	233	8	3.4	5	2.1	Holi *et al* (2007)
Cambridge	30	1	3.3	0	0	
Oxford	24	0	0	1	4.2	
Imperial College	29	1	3.4	1	3.4	
University College London	9	2	22.2	0	0	
Edinburgh	26	0	0	0	0	
West Midlands 1983 - 2013	102	6	5.9	0	0	Current work
Aston	7	2	28.6	0	0	
Birmingham	29	2	0.1	0	0	

Coventry	11	0	0	0	0	
Keele	6	0	0	0	0	
Staffs	6	0	0	0	0	
Warwick	43	2	0.1	0	0	

Table 8.4 Percentage of USOs obtaining a trade sale or IPO (author-derived data)

Analysis

Table 8.4 shows a consistent theme across the universities from different countries of extremely low levels of successful exits for universities from their USOs via trade sales or IPOs. While certain universities such as Aston or University College London show high rates of trade sales, albeit on very low volumes of USOs created (which interestingly implies that these two universities may independently have followed a similar strategy of only creating USOs with a high quality underlying technology to develop), the long term average of successful USO trade sales is only around 5% for UK universities. It should be noted that the number of studies available for consideration is small, and care must be taken over some elements of comparability such as the fact that the period under study by Holi *et al* (2007) is extremely short, so this may underrepresent the true number of trade sales, and indeed given the elite nature of some of the universities included in that particular study one might expect the rate of sales to be higher than those seen in the West Midlands region.

The overall rates of USO IPOs observed in the study are lower still, although the universities reviewed in Holi *et al* (2007) do at least show that some USOs reached this stage, unlike USOs from the West Midlands and ETH Zurich, none of which proceeded to an IPO. Oskarsson and Schläpfer (2008) attributed the low rate of IPOs seen in Zurich to the lack of a junior capital market in Switzerland compared to the UK, which has London's Alternative Investment Market, and the lack of attractiveness of the Swiss venture capital market to international investors, partly for regulatory reasons, although it does appear from other data that founders, family and friends of the ETH Zurich USOs invested personally much larger sums than their equivalents into UK and US USOs (Shane, 2004 and Mason and Harrison, 2001). It is noticeable that significantly more US USOs achieved an IPO as shown by Zhang (2009), which is in line with significant empirical and anecdotal evidence that US USOs are the most successful worldwide. This has been attributed to various factors, including an entrepreneurial culture unafraid of risk-taking and failure, and the observation that the US has the most attractive capital markets for investors.

While the overall trend may be in line with the predictions of signalling and agency theories, the lack of significant differentiation between very strong research universities such as the Golden Triangle and Post-92 universities is probably not the expected result. These results probably demonstrate that information asymmetry and uncertainty remain very significant factors in determining the ultimate success of a USO, and on this data far more so than the research strength of the parent university. These two factors may serve to discourage potential investors to support a USO to IPO, although other factors may be at stake such as the wider stock market climate in the period under review and the wider appetite for IPO among all firms in general.

Overall, it seems likely that no significant financial amounts have been received by UK and European universities as a result of their USO programmes. Oskarsson and Schläpfer (2008) note that the exit rates observed for the ETH Zurich USOs is very low compared to other academic studies on venture capital-backed companies e.g. Metrick (2007) who observed a 5 year exit rate of 33% in a study of almost 12,000 venture capital investments. This observation has significant implications for policy makers who have sought to emphasise USO creation within the field of academic entrepreneurship.

University	Total USOs	Total funding (£'000)	Funding per USO (£'000)	Source
ETH Zurich 1998 - 2007	82	153,855k CHF = 65,470	798	Oskarsson and Schläpfer (2008)
10 UK universities 1998 - 2002	172	494,446	2,874	Minshall and Wicksteed (2005)
Cambridge, Oxford, Imperial College, University College London	99	344,572	3,481	
Edinburgh, Newcastle, Southampton	36	121,806	3,384	
Cranfield, Loughborough, Strathclyde	37	28,068	759	
West Midlands 1983 - 2013	102	67,683	664	Current work
Aston	7	4,481	640	
Birmingham	29	5,875	203	
Coventry	11	1,132	103	
Keele	6	3,498	583	
Staffs	6	1,332	222	
Warwick	43	51,365	1,195	

Table 8.5 Total third party external funding obtained by a university (author-derived data)

University	Total USOs	Total funding (£'000)	Funding per USO (£'000)	Source
ETH Zurich 1998 - 2007	24	153,855k CHF = 65,470	6,411k CHF = 2,728	Oskarsson and Schläpfer (2008)
US universities	606		$23.55m = 13,853	Zhang (2009)
10 UK universities 1998 - 2002	111	494,446	4,454	Minshall and Wicksteed (2005)
Cambridge, Oxford, Imperial College, University College London	71	344,572	4,853	

Edinburgh, Newcastle, Southampton	25	121,806	4,872	
Cranfield, Loughborough, Strathclyde	15	28,068	1,871	
20 UK universities 2001 - 2006			2,300	Holi *et al* (2007)
Cambridge			5,500	
University College London			4,300	
UK universities 1990 - 2007	78		19,754	Mueller (2010)
West Midlands 1983 - 2013	54	67,683	1,253	Current work
Aston	6	4,481	747	
Birmingham	14	5,875	420	
Coventry	4	1,132	283	
Keele	4	3,498	875	
Staffs	1	1,332	1,332	
Warwick	25	51,365	2,055	

Table 8.6 Funding obtained per USO that attracted funding (author-derived data)

Analysis

Table 8.5 illustrates the significant success of Warwick as a university in attracting funding for its USOs compared to ETH Zurich, with the rest of the West Midlands region at a much lower level than these. Both ETH Zurich and all of the West Midlands universities attracted significantly less funding per USO than the majority of the strong research UK universities considered by Minshall and Wicksteed (2005). As already noted, this study considered USOs from ten universities split into three slightly arbitrary categories. Universities with large research budgets, containing the elite research universities of Oxford, Cambridge, Imperial and University College London secured significantly more funding than all universities in the other two studies, as did other large universities in large cities (Edinburgh, Newcastle and Southampton). This finding would appear to show that the research excellence of a university bears a link to the amount of money raised from external third parties by its USOs. On first principles, this observation is in line with signalling and agency theories as large research-led universities are more likely to develop high quality technologies which are attractive to external investors should the university seek to develop the technology through the vehicle of a USO. This is then likely to lead to a virtuous circle in which external funders actively seek out investment opportunities at the university, which in turn set up the support structures in the shape of a well-equipped TTO or other incubatory facilities to further support USOs. Agency theory supports such an interpretation as TTOs and investors build trust and have their goals aligned. Some

care should be exercised in assuming a simple relationship, however, as ETH Zurich ranks highly in worldwide university rankings, and factors such as the availability of external funding in a different country will also need to be considered. The third category of university in Minshall and Wicksteed's (2005) study, namely that of universities with smaller research budgets but with a higher percentage of research funds coming from UK industry, shows a much lower level of funding than the other two categories and one that is highly comparable to ETH Zurich and the overall average for the West Midlands universities. Birmingham is noticeably weak in attracting funding despite being a Russell Group member, while the Plate Glass and Post-92 universities are also low, in line with the predictions outlined above.

Table 8.6 provides a fuller picture of USO funding than Table 8.5 as it includes a number of other studies, but also considers a slightly different funding metric, namely only considering USOs that actually attracted funding. The findings above still hold in that a link between research excellence of the sponsoring university and attraction of external funding for its USOs can be made in line with signalling and agency theories. In terms of individual universities, ETH Zurich shows a significantly higher level of funding than West Midlands universities compared to the previous table which implies that the latter created a relatively large number of USOs that did not attract any funding at all. This is consistent with the observation of low survival rates observed for USOs from West Midlands universities in the current study, implying that that they are relatively unattractive to funders. The research premium can still be seen for the elite UK universities compared to the West Midlands universities and ETH Zurich, and this is consistent with the study of Holi *et al* (2007) which also considered a number of elite universities. In addition, given that ETH Zurich is a strong research university, it is a finding in line with signalling theory, and only the Russell Group member Warwick comes close to matching it within the West Midlands region.

Table 8.6 again shows a pattern in terms of funding for USOs appearing to be correlated with research excellence with the majority of West Midlands universities at a low level other than Warwick, ETH at a higher level and certain elite universities such as Cambridge at a significantly higher level still. However, all European universities in the study achieve significantly less funding that the US as shown in the figures of Zhang (2009). While Zhang's (2009) study only included USOs that had already achieved third party venture capital funding i.e. not including soft funding such as UCFs, and hence only including the most successful USOs, this is likely to be representative of observed trends of the US having a much bigger venture capital industry that is prepared to stake significant sums of money into promising start-up companies, and where culturally there is much less stigma attached to failed companies than is seen in Europe and the UK. It should also be noted that one Warwick USO in the current study achieved over £14 million of external funding, such that Zhang's (2009) figures are not unobtainable for the right UK USO.

The study of Mueller (2010) is puzzling in that it shows an extremely high level of funding achieved by UK USOs which is not consistent with that seen in the current work or with the other studies of other UK universities in the tables above. Indeed, it claims that UK universities are significantly more successful that US universities in attracting external funding for USOs, which is not a conclusion supported anywhere else in the literature. It may be that the database used in this work omitted many less successful USOs, although even this is unlikely to account for such a difference compared to other works.

8.4 Conclusion

Comparison of the financial performance of West Midlands USOs with those generated by other universities from the UK and abroad reveal some interesting issues which will be of relevance to policy makers, investors and academics alike. While directly comparable academic studies are small in number, universities in the UK, Europe and US have been included, providing good geographical coverage. The chosen theoretical frameworks of agency and signalling theories would predict higher rates of survival and funding obtained by USOs from stronger research universities, and the data from this range of universities can be analysed to see if it is line with these predictions.

In terms of survival, the current study shows significantly lower survival rates for USOs in the West Midlands than other universities of a higher research strength, which is tentatively in line with the above theories. However, the differences are so significant that it is unlikely that research strength is the sole factor, especially as the West Midlands has some strong research universities in the form of Russell Group members Birmingham and Warwick. It is suggested that these results may be as a consequence of the more accurate USO datasets constructed in the current work, and the ignoring of twilight USOs in previous studies, as their survival rates seem unrealistically high, especially when compared to other start-up companies that are not USOs.

The ability to attract third party external investment shows greater variation between countries. There appears to be some sort of link between research excellence of a university and the ability of its USOs to attract investment, in line with the predictions of the above theories, although more work will need to be performed to establish this link, which is not likely to be simple in nature, and can be influenced by a number of other factors not considered in detail here such as industry sector of the USO, institutional policies, the USO management team (Huynh *et al*., 2017) and the identity of the academic founders. Other UK universities of higher research excellence such as the Golden Triangle show higher investment than the West Midlands region, and European regions likewise. However, as expected, such results are overshadowed by the ability of US USOs to attract finance, which is likely to be a direct consequence of the attractive investment culture in the US towards young companies with technology to commercialise.

Finally, the ability of USOs to generated financial returns for their parent universities by a successful exit via a trade sale or IPO demonstrates a similar pattern to the attraction of funding. In terms of countries, the US shows significantly higher rates of IPOs than other countries in line with the explanations above. However, for all countries the rate of exit is very low, suggesting that universities worldwide have not benefited significantly from a financial perspective from undertaking their USO creation programmes. These findings are partially in line with the predictions of the theories used, but the lack of differentiation and the overall low levels of exits, even amongst elite research universities, is not necessarily fully in line with expectations.

In general, information asymmetry and uncertainty can be seen to remain significant handicaps for all universities, regardless of research strength, and for external investors in identifying USOs that will succeed financially. Levels of exits remain extremely low, despite in some cases significant funding being obtained, and well below the levels seen for other financially-backed start-up companies, leading to hard questions for policy makers who have encouraged USO formation on a global basis over a number of years.

9. Conclusions and final discussions

9.1 Summary of key findings

This thesis uncovers a number of important findings in the area of the financial performance of USOs, both within a regional context for the West Midlands area, and from comparisons with the results of other academic studies in this field, both in the UK and overseas. The overarching research question from Chapter 1, namely 'Have USOs generated by West Midlands universities been successful in terms of financial performance?', which is a broad and open-ended question, has been explored by identifying the most appropriate metrics with which to analyse financial performance of USOs, and while the answer to such a broad question needs to be discussed at length, it is clear from the analysis performed that, to date, the USOs investigated have not been financially successful. To provide a theoretical justification for the analysis, two frameworks of signalling and agency theories were chosen and data interpreted, as far as possible, in the light of their predictions. The supplementary research questions identified in Chapter 4 are addressed below in the light of previous discussions.

9.2 Research question a) – how do USOs originating in the West Midlands perform in terms of survival?

The West Midlands USOs in the current study display a number of interesting features in terms of their survival data, although analysis is challenging given the lack of relevance of the two theoretical frameworks selected for this work. There are a surprising number of survival performance metrics across the universities that show remarkably consistent results, a feature which would be unlikely to be expected given the wide range of types of universities in the region. The mean time to failure for a USO is one such metric, as is the shortest observed lifetime of a USO from each university. In addition, the mean time to failure for USOs is much longer than that observed for non-USO start-up companies in the literature, an observation which reinforces the findings of other studies. Another interesting observation is that, in line with other studies e.g. Oskarsson and Schläpfer (2008) looking at USOs from a different country, 7 years appears to be a key cut-off date in the life of a USO after which time investors will no longer support the company if it has not sufficiently developed its technology to reach or be close to a commercialisable format. However, great care must be taken in drawing any conclusions about USO survival due to the wide range of factors that can influence company survival, and which have not been analysed in detail in this work due to the restricted nature of the data collected.

One of the key findings of this thesis, and an area that has not been discussed in detail in the existing USO literature, is the identification of the group of USOs that have been designated 'twilight USOs'. These are USOs that have not formally been removed from the register at Companies' House, but have effectively ceased to develop their underlying technology any further due to a lack of financial resources, and a significant period of time has elapsed since their last receipt of funding. They have thus effectively ceased to trade, although it is possible that they may recommence trading due to a change in circumstances. Twilight USOs are an important category of company as they provide a possible explanation for the discrepancies seen and noted in the literature to date, but not adequately explained, of why the survival rate of USOs seems to be so high when compared with

other start-up companies, including ones that are developing new technology. When twilight and formally dissolved companies are grouped together, the overall failure rate is much closer to those seen for other start-up companies, and is again remarkably consistent across the universities within the region.

In general, the level of consistency found in the survival data would not be expected from signalling theory, and leads to the tentative conclusion that survival is not an effective metric in analysing financial performance of USOs, which is in contradiction to the literature reviewed to reach a decision on effective metrics for this work e.g. Library House (2008). Again, however, the relatively small size of the sample would imply caution should be taken in reaching any firm conclusion.

9.3 Research question b) – how do USOs in the West Midlands perform in terms of attracting external third party investment?

The range of performance metrics associated with the attraction of external finance by the West Midlands USOs show much greater variation across the universities than the equivalent survival data. This metric may therefore be a more accurate proxy for the successful financial performance of a USO and give more information about the approach adopted to the creation and maintaining of USOs by the parent university.

In terms of the numbers of USOs attracting funding, a wide variation is observed across the region with some universities such as Aston displaying a very high percentage with a small number of USOs created, again implying that the university has focussed on only creating USOs with high quality underlying technology which is attractive to external investors. The absolute amount of funding received by a university's USOs varies widely, with Warwick showing significant success in this field by attracting more funding than all the other universities combined, and also more funding obtained per USO, although the outperformance of this metric is less marked given that Warwick also created the most USOs in the region. Birmingham falls somewhere between Aston and Warwick in its behaviour in that it created a large number of USOs, but attracted only a relatively low amount of funding per USO, a situation that has been unfavourably identified as occurring in the UK in the past (Lambert, 2003). In general, the predictions of the theoretical frameworks are seen , in that stronger research universities attract more money from external investors for their USOs, but the relationship is not a straightforward one given the size of Warwick's outperformance compared to the region's other universities.

The types of external investment attracted by USOs also shows some interesting results. All universities were able to attract some external private investment, but not all accessed the UCF money made available by government. Those universities that did take particular advantage of UCF money, Birmingham and Warwick, created the largest number of USOs, in line with signalling theory's predictions above on USO numbers, whereas Aston did not obtain any UCF funding but relied on other sources to develop its small number of USOs.

In addition, figures can easily be distorted by the presence of a very successful USO, as seen here with Staffs, making the approach favoured by this work of a detailed analysis of performance by individual USO of great importance in obtaining accurate information for interpretation.

9.4 Research question c) – how do USOs originating in the West Midlands perform in terms of reaching a financially successful IPO or exit for the university?

The performance metrics that provide information about exits for investors from USOs reveal little success for the West Midlands region as a whole from a financial performance perspective. None of the USOs considered throughout the whole of the period under review proceeded to an IPO. Six USOs were subject to a trade sale and one to a merger. However, in financial terms, only one of these exits is likely to have given rise to a profitable exit for the parent university, a Birmingham USO called Entice Technology Limited.

The results from the region demonstrated no connection between the number of USOs generated by a university, or the amount of external funding attracted, and an exit from its USOs for the university. Again, Aston was the most successful in terms of moving its USOs to exits, while Warwick was relatively unsuccessful despite attracting a significant amount of external funding. Such a finding has implications for a number of stakeholders in USOs, as discussed in more depth below.

This finding is very difficult to explain using the chosen theoretical frameworks as an exit is simply a special form of external investment, so one would expect strong research universities with significant funding such as Warwick to see a number of successful exits. The research strength of a university therefore appears of limited relevance. It is possible that the timescale of the study was too short to observe some exits, and again the sample sizes are relatively small. It is clear that information asymmetry remains a key factor, with even experienced external investors, in the shape of UCFs and VCs, unable to pick 'winners' in this study. The only successful USO exit came from a company with no external funding, highlighting the crucial role of the technology, but also the inability of external funders to predict its success.

9.5 Research question d) – how does the attraction of external funding affect a USO's survival?

The findings of this work are tentatively in line with that predicted under signalling theory, namely that USOs that obtain external financing survive for longer as they send out favourable signals to stakeholders. However, the literature is split on this point, and the findings of this work are by no means conclusive, particularly as the sample analysed is small and the majority of the USOs obtained very little funding. Again, the lack of distinction between USOs seen leads to the conclusion that survival is not a particularly effective metric with which to analyse USO financial performance.

9.6 Research question e) – how does the attraction of external finance affect a company's ability to reach an IPO or successful exit?

In line with the above analysis, there is no discernible link between the attraction of external finance and the reaching of an IPO or successful exit.

9.7 Research question f) – how does the West Midlands USOs' financial performance compare to USOs from other universities in the UK and abroad?

While comparing and contrasting results obtained from universities within the West Midlands region leads to some interesting observations, comparisons with the small number of existing academic

studies in the field of financial performance of USOs are of even more potential value as a contribution to the literature.

The current study generally shows much lower rates of survival amongst its USOs than all others in the literature, particularly when twilight USOs are included. It is likely that this observation is a consequence of less complete and accurate populations of USOs being used in previous studies rather than simply the inclusion of twilight USOs in the current work, or the possibility that USOs from the West Midlands are generally of inferior quality than all other studies performed to date. As discussed further below, this finding is a key contribution of the current work to the existing literature. The number of single university studies in the literature is very small, and are mainly of prestigious institutions making comparison with West Midlands universities difficult. Again, this finding suggests that survival is not a particularly strong financial performance metric for USOs.

In terms of external investment, the results in terms of funding attracted by the West Midlands USOs are much more comparable with those of previous studies of UK USOs from other universities, which provide confidence about the results from all of these studies. It is noticeable that there appears to be a trend between the research excellence of the parent university and the amount of funding achieved for each of its USOs, and universities such as Oxford and Cambridge are amongst the highest in terms of attracting funding in the UK. This observation confirms empirical findings in the literature to date. There is a significant lack of studies from other countries that look at comparable metrics, although one existing study from the US (Zhang, 2009) shows a much higher level of funding obtained for USOs than the UK, which again confirms a number of empirical observations within the literature. A study of USOs from ETH Zurich (Oskarsson and Schläpfer, 2008) shows lower amounts of funding obtained than many UK universities, although this was attributed by the authors to a lack of a junior capital market in Switzerland comparable to the Alternative Investment Market (AIM) in London. These are in line with the findings of this work regarding the line between research strength and external funding, and with the predictions of signalling and agency theories as already noted, which provides some comfort over the doubts indicated earlier over the distortion of Warwick's results in the region.

Exits from USOs via trade sales or IPOs are low across all studies in the literature, so the West Midlands as a region is not particularly poor in this regard. As above, the US has a superior record to other countries in terms of this performance metric, although the very small number of comparable studies means any conclusions must be drawn with great care. The predictions of signalling and agency theories are not strongly supported in this area as greater differentiation between universities would be expected, and highlights the fact that the information asymmetry identified earlier may be a wider UK and international phenomenon.

9.8 Research question g) – is the attraction of external financing by USOs influenced by the research strength of the parent university?

On first principles, the findings of this work support the views that increased research strength of the parent university impacts positively on the amount of external funding obtained by its USOs. This is in line with the predictions of both agency and signalling theory. However, a number of studies in the literature have found no such relationship. It is likely that many other factors are at stake, including the attitude of the TTO to obtaining funding and the strength of its networks, as even in the current study the success of Warwick in attracting funding distorts the overall picture for the region. Again, the finding is a useful contribution to the literature in this field, although greater

samples of universities and USOs should be considered if greater certainty over the conclusion is required.

9.9 Research question h) – is the number of USOs created influenced by the research strength of the parent university?

The current study shows a positive correlation between research strength and number of USOs created by a university, a finding which is not in line with some previous studies. The two Russell Group universities in the region, Warwick and Birmingham, create significantly more USOs than the other universities, which are of lower research intensity. However, such results should be treated with caution, as the sample of universities and USOs investigated is small, and the distorting presence of UCF money from the UK government specifically to create USOs may explain the difference from prior studies, where TTO policy was shown to vary significantly by university in respect of USO creation. The finding of this work does, however, correspond with the prediction of signalling theory, so should be of value in ongoing discussion on this point in the literature.

The identification and classification of USOs in the West Midlands reveals some interesting trends. The number of USOs created by any university is not always simple to predict or link to any variable, although it appears from the current work, in contrast to some earlier studies cited, that the more research-intensive universities in the fields of science and technology often tend to create more USOs, in line with what would be predicted under signalling and agency theories, given their additional technological resources and reputation. However, some strong research universities create few USOs, apparently focussing on creating and maintaining a small number of high quality technologies, while a number of universities (usually more modern, less research-intensive institutions) do not create any USOs at all.

In terms of USO formation dates, within the West Midlands region, USOs had been formed from at least 1983. Creation rates increased dramatically from about the year 2000, which can probably be attributed to the introduction of UCFs, a government-backed funding source specifically aimed at encouraging USO creation by UK universities. As the initial amount of funding provided was consumed, the rate of creation of USOs dropped, and this was also affected by a range of additional external factors. In line with agency theory, which predicts different TTO policies in respect of USO formation, individual university behaviours can be seen to be a factor.

The presence of UCFs may also distort the above finding of a correlation between university research strength and number of USOs created, given that the significant sums of money were specifically designated to USO creation. In line with other studies from the literature, life sciences and IT were the two most popular sectors in which USOs were created in the West Midlands region. This finding is also in line with the predictions of signalling theory as universities are particularly well placed to develop disruptive technologies in these fast changing sectors, with the highly specialised knowledge of their academic and research staff and their ownership of high quality research facilities, giving their USOs a potential competitive advantage through their technological resources.

9.10 Contribution to theory

On a theoretical level, the study confirms that signalling and agency theories are of value as theoretical frameworks within which to conduct research on the financial performance of USOs. It is clear from the above analysis that not all of their predictions are reflected in the data obtained in

this work, and this is maybe to be expected, given the complexity and range of potential factors that influence a newly-formed company's subsequent financial performance. However, they at least offer a reasonable framework within which to discuss and analyse the wide range of results obtained.

Of the two frameworks considered, agency theory is the less useful in analysing the results obtained, which is possibly as expected given the limitations in its usefulness identified in Chapter 3. In this work, the principal is a potential investor in the USO and the agent the TTO. Not all USOs will actively seek external investment, so the model is of little value in these cases. More fundamentally, as identified earlier, agency theory is only really of value to explain behaviours before investment is obtained (Arthurs and Busenitz, 2003) as once this occurs, the investor and TTO are likely to have goal congruence, making comparison between universities difficult. In addition, prior studies may predict little reason for a TTO to act as an agent under agency theory, given that most TTOs will be keen to attract investment for their USOs.

Signalling theory has been shown to be of value by the current work, which backs up its use in prior studies of USOs e.g. Mueller (2010), where new companies and their signals are analysed by external parties to overcome information asymmetry and uncertainty. In this study, the USO acts as the signaller and the prospective investor as the receiver, and the theory can be expanded to comment upon a range of possible signals given out by the USO, such as the strength of underlying technology and quality of management. These discussions can be extrapolated to comment upon the findings of the other performance metrics including the number of USOs generated by a university and their survival. However, as predicted from Chapter 3, given the narrow range of financial data collected and the underlying complexity and range of factors that influence the financial performance of a company, the theoretical explanation for data is often tentative at best.

On first principles, both theories would predict that strong research universities would produce more USOs of a scientific or technological nature, would attract more funding, would survive for longer and see more successful exits. However, the exact picture throughout the West Midlands region is considerably more complex, and while some of the predictions from theory are observed, others are not, which leads to the particular strength and value of this work. Analysis of the predictions of theory against the observed data in depth was made on a regional basis in Chapter 7 and against existing studies from the UK and abroad in Chapter 8.

On a regional basis, the frameworks correctly predict that strong research universities generate more USOs due to the strength of the signal of the research strength of the university, which is again seen in the total investment obtained by a university's USOs, where agency theory would predict a lack of goal incongruence for a university keen to commercialise its technology. However, even here there are slight caveats with Aston creating a low number of funded USOs, showing that individual TTO policy can be important. The survival of USOs is surprisingly consistent across the region, which would not be expected from the theoretical models, and the lack of successful exits is again not in line with predictions. This last point shows that uncertainty and information asymmetry are two crucial factors which for this particular region appear to overcome the possible range of signals that even USOs from strong research universities can send out to potential investors. This is exactly what would be expected from USOs, which are new companies often attempting to commercialise unproven technology.

On a national and international comparison, the predictions of the theories are seen to be more closely followed for data on investment and exit, albeit on low volumes of comparative data. Again, information asymmetry and uncertainty remain key factors which appear to prevent any simple correlation being seen.

Finally, in contrast to other works in the literature, which rely heavily on the RBV framework to analyse their results, this work has demonstrated that it is possible to look to other frameworks, which when combined with confidence in the accuracy of the underlying data allows conclusions of value to be drawn.

9.11 Additional contributions to the literature

The current study contributes to the literature on the financial performance of USOs in a number of further ways.

From a data perspective, many of the key findings discussed above make a significant contribution to the literature. Possibly the most significant finding is that of the phenomenon of twilight USOs, which provides an explanation to a long-debated observation within the literature over the apparently relatively long lifetime of USOs. This has not been fully explained to date, especially within the context of the observed apparent poor financial performance of USOs.

Secondly, the different behaviours of universities with regard to their USO programmes has not been given great prominence before in the literature. Through consideration of a range of performance metrics, this study builds up a detailed picture of how different universities within the same geographical region have approached their third mission of development of academic entrepreneurship in respect of USOs in different ways. The West Midlands region contains a number of very different kinds of university ranging from research-intensive Russell Group members to very recently founded universities whose focus is more upon teaching than research. As a result, a wide range of behaviours of universities has been observed. Aston appears to have focussed on creating a small number of high quality USOs while Warwick has instead maximised its use of government UCF funding to create a large number of USOs and attract a great deal of external third party funding, yet in terms of exits and financial benefits to the universities the results are very similar (and very low). Most of the other universities fit somewhere in the middle of this range of behaviours, while a number of universities have not created any USOs at all, in line with prior observations.

Thirdly, this study fills a surprising gap in the literature with regard to comparing and contrasting financial performance results from existing studies, especially with USOs from different countries. All performance metrics are compared with other studies, the majority of which are studies of other UK universities although not specifically on a regional basis. Overseas studies include USOs from ETH Zurich (Oskarsson and Schläpfer, 2008) and the US (Zhang, 2009).

Fourthly, this study adds to the literature in regard to the methodology of the creation of the accuracy and completeness of its USO population. As already noted, a large part of the time spent on this work was connected with the creation of the USO database, and it appears likely that the impact of this can be seen in the difference in some of the performance results obtained compared with those from previous studies, particularly with the metric of survival of USOs which appears to have been consistently overstated until the current work as USOs that failed some years before any study is conducted are often missed out completely from the population tested.

Finally, this study provides a useful assessment over the value of a number of performance metrics to assess USO financial performance. Of the metrics selected, the number of USOs generated is a poor proxy for their financial success. Survival also proves to be a poor metric, despite its use in earlier works, given the surprising consistency across companies. External investment is of some value, but even so there is little correlation in the West Midlands region with successful exits, which

may be said on the current work to be the best metric in assessing the true success of a USO from a financial perspective.

9.12 Implications for USO stakeholders

As a result of the findings above, this thesis identifies a range of issues arising for different stakeholders in USOs. The main stakeholders considered are USO management, governments (including other policy makers), external investors into USOs and the parent universities themselves (along with their TTOs and other incubatory infrastructure created to manage USOs).

9.12.1 USO management

Given the wide range of types of USO identified in the work, it is difficult to generalise in terms of implications for USO management. While all USO managers will wish to see their company's technology developed to a point of commercialisation, the journey they are prepared to take to reach that point will vary significantly between, say, a VC-funded USO and a lifestyle USO.

The main implication from the work is that the majority of USOs will not succeed from a financial perspective i.e. they will not commercialise their technology successfully. There is little chance of a USO surviving to become a successful and profitable company and the prospects of an IPO or successful exit are very low. However, the ability of USO management to obtain funding from external parties is more likely.

The nature of many successful entrepreneurs means that such pessimistic forecasts are unlikely to dissuade managers from joining USOs if they genuinely believe that the technology involved represents a significant scientific breakthrough and hence a strong candidate for commercialisation. Even within the West Midlands, there are a small number of successful USOs. However, the profile of USOs in the West Midlands suggests that managers should be realistic about the prospects of financial success, and maybe look to join up with well-funded entities, either in industry or other USOs, as the likelihood of a single USO becoming successful alone is remote.

Where the USO management is simply creating a company to formalise profitable consulting work, or as an entity with which to attract research grants, the emphasis on activities such as IPOs or attracting VC funding is much less significant. As a result, such lifestyle companies are likely to continue with little to learn from the fate of other USOs with a much smaller timescale for financial success.

9.12.2 Governments and other policy makers

As already discussed in Chapter 2, governments in the UK, and indeed worldwide, have at various times introduced policies designed to encourage the formation of USOs. USOs were seen as having great potential for creating highly skilled jobs and developing new disruptive technologies to the benefit of the national economy. Government support was often in the form of providing funding in the early stages of the life cycle of a USO to provide the necessary financial resources to the company to allow it to meet the costs of development of their underlying technology before any revenue had been generated. In the UK, the main government policy in this field was the creation of UCFs for this purpose.

As noted above, it is clear that while UCFs were indeed used to create significant numbers of USOs, and certainly far more than in the years before 2000 when such funding became available, the financial returns to universities in the West Midlands have been almost negligible. It is noticeable that Aston, which did not access any UCF money, was just as successful in terms of financial returns as Warwick, which used UCFs to create large numbers of USOs. From the viewpoint of enriching universities and creating significant long term wealth for the national economy, the UCF strategy conceived by the UK government appears to have been a failure.

However, other indicators appear to show that the strategy may have had some success in that Warwick in particular, and Birmingham to a much lesser extent, were able to attract significant sums of money from external third party investors. It is likely that such investors were encouraged to participate with the background guarantee of some government money to the USO to meet some of its start-up funding costs. Such money may not have been invested had the UCFs not been set up, although this study does not investigate this area in great detail. Some university technologies have therefore clearly been further developed without having to use public money, and skilled jobs have been preserved and even created within USOs, thus adding to the knowledge base of the UK, even though the long term financial results appear to be limited.

There may also have been indirect benefits to the economy such as creation and maintaining of supply chains which interact with USOs and the parent universities, including companies in other sectors, especially small and medium-sized entities in the local area. In addition, knowledge transfer may have occurred even after USOs failed, as staff left and joined other companies, taking with them knowledge and skills developed during their time at the USO.

Overall, the picture is therefore mixed from a policy perspective for government. In the context of total government expenditure the amount spent on USOs via UCFs was immaterial, but it is not clear if the money could have been spent in a more effective way or on different projects and achieved better results. It is also emphatically clear that no significant company was created from USO origins within the West Midlands region. The debate will doubtless continue, but at least with studies such as the current one the hard facts in terms of financial impacts will now be available should a similar programme be considered in the future. It may also be the case that USOs have given better results when they are generated from elite UK universities, but that regional universities such as those from the West Midlands outside this elite cannot match them and that the USO programme has not succeeded for them.

9.12.3 External investors

Unlike government and other policy makers who may have wider viewpoints, external investors are usually almost solely concerned with the financial performance of any company in which they propose to invest. As a result, the lack of any significant exits from USOs in the West Midlands region, despite the significant sums invested by third party investors, means that the overall programme of USO creation has not been a success from an investor's perspective.

It should be noted that USOs, like many other small start-up companies whose reason for existence is to develop a technology to the point where it can generate revenue, are high risk investments for any investor given the significant information asymmetry and uncertainty in this sector. As a consequence, it is often the case that a high proportion of investments in this sector of companies will fail and the investors will lose all their money, having accepted the risk that this is likely to happen. However, given the long timescale of this study, the lack of any successful exits means that

USOs in the West Midlands have proved poor investments. This is in contrast to some empirical studies of USOs in the US, some of which have grown to significant size, as well as some USOs from more elite academic establishments in the UK. As a result, external investors may be more reluctant in future to invest in USOs, particularly those generated by universities outside the elite UK research-driven institutions, given results such as those from the current study.

9.12.4 Universities

The response of West Midlands universities to the results of this work is not necessarily likely to be straightforward. On the one hand, there is likely to be some disappointment among finance departments that no USO has been created that led to a significant financial return to the university. It is clear that financial returns cannot in any case have covered the running costs of TTOs, their staff costs and the costs of other incubatory facilities for USOs.

However, given that universities are publicly funded, this lack of financial return may not be a significant concern. USOs have achieved external funding by third party investors to develop university technology which would be unlikely to have happened in the absence of USOs. In addition, university staff will have gained valuable experience of the USO creation process and running these companies, gaining some commercial skills. Valuable networks with potential investors will also have been developed, and this may bear fruition under different programmes between university and industry or even in the future should a high quality USO be developed at a West Midlands university.

Throughout the wider UK university scene, it is likely that the results of this work will be of value to universities in their assessment of whether they should try to create as many USOs as possible, or try to focus on a few, potentially high quality USOs. The experience of Aston, which did not access any UCF funding yet still saw some exits from its USOs, is of particular relevance in the current climate with the lack of any significant public financing to succeed UCFs.

9.13 Limitations and suggested further work

While this study contributes significantly to the existing literature on the financial performance of USOs, like all pieces of academic research it has a number of significant limitations in its scope. This situation then leads to proposals for further work in the field to help develop the findings and conclusions noted above.

The chief limitation in this work, in common with most others in the field, is the size of the sample of USOs collected and analysed. While the sample size of 102 USOs from the West Midlands is of a respectable magnitude when compared to many other studies in the field, as noted in Chapter 8, it is dominated by the two universities of Birmingham and Warwick which together contribute over 70% of the USOs. While interesting trends are still observed for the other universities in the region, the small number of USOs generated by each means that results must be treated with care, especially when trying to make comparisons with other universities or with other performance studies.

One of the key features of this study which sets it apart from others is the amount of time spent in collating a very accurate database of USOs using a wide range of independent sources. As a result, great confidence can be placed in the completeness of the database compared to other studies, and this is borne out in a number of ways including very different findings on USO survival compared to prevailing views in the field. However, the process of creating the database is time-consuming and

was a limiting factor in this study within the available timescale which prevented expanding the work to other regions of the UK. The techniques used to create the database in this work can be fully replicated for other studies, leading to ease of comparison of results with other regions and countries, which is a great strength of this work within its positivist research paradigm.

There is also some limitation with the amount and range of data that can be collected. The lack of publicly available data on financial performance of USOs is a common theme within the literature e.g. Zhang (2009) so this situation came as no surprise. In addition, as already noted, the UK is particularly limited in the amount of publicly available data relating to companies as generated by Companies House with the ability of small companies to file abbreviated accounts with very limited financial disclosure required. As a result, the data collected in this work is fairly limited in scope, although because of the accuracy of the USO database interesting conclusions can still be drawn. For example, while it was possible to obtain data on the total amount of funding by a USO, it was not possible on a consistent basis to split this down into different funding rounds with amounts and dates, which would have allowed some more interesting results to be obtained. Other studies in the past have had to resort to approaching the USO direct to obtain this information, which is likely to reduce the accuracy of the data collected. As a result, it is often difficult to draw conclusions about apparent trends as a wide range of factors that cannot be considered here may also have an impact on the results observed. The theoretical frameworks used can only provide a fairly simplistic level of analysis of results, meaning any conclusions are often tentative in nature.

Suggestions for further work on one level are straightforward, namely to perform a number of similar studies for different regions of the UK and different countries to provide more opportunities for comparisons against the results of this work. More studies will reveal whether the West Midlands region has unusual properties or whether the findings of this work are comparable with other regions. It should be noted that the findings on total external investment obtained by West Midlands USOs appeared reasonable when compared with other studies of UK USOs, so it is not expected that significant differences would be found. However, it should be noted that there is a significant lack of studies of overseas USOs, so this may be an area of priority in the field.

Further investigation should also be made into the elite UK universities using the methodology of this work to see if the results are consistent with those already in the literature. As already noted, studies of financial performance have been made of some of these universities e.g. Oxford (Lawton Smith and Ho, 2006), and such universities have been prominent in promoting their apparent financial successes. However, it is noticeable even from the relatively small number of studies considered in this work that their financial success is relatively modest, even with questions about the accuracy and completeness of the USOs databases used in these works. It is not inconceivable that reworking some of these studies using the rigorous methodology of the current work, which removes the opportunity to remove historic, failed USOs from the database, could yield very different results to those seen previously. This is an area of priority for further work within the field of UK USOs. Following on from this, a more detailed investigation could be made examining the link between research excellence of a university and the financial performance of its USOs, which has not been considered in great depth to date.

This study differs from other PhD theses in this field e.g. Mueller (2010), de Cleyn (2011) in that it does not attempt to obtain financial data through the means of sending questionnaires to USOs and then using regression analysis techniques to attempt to derive relationships between USO performance and a number of variables. It could be expanded with some more qualitative data, probably to include discussions with university TTOs to see if their policies for creating and managing USOs match up with observations made from the data obtained in this work. This would add a new

dimension to the current work, but its absence does not detract from its existing findings, which find sufficient differences from existing views in the field to make this a worthwhile standalone piece of work within its academic field.

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